POWER

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Different Yesterday, Today and Forever

Consider the calendar. It changes every day. So does human knowledge. The solemn science of centuries ago is the rankest superstition of today. The best established scientific (so-called) fact of today may explode with a loud report tomorrow.

Don't be too positive. Remember, lightning was one of the greatest terrors of mankind till Benjamin Franklin took a flier in kites. Now one man presses a button to start a world's fair. Man has done a good deal but he doesn't know it all. Vessels have crossed the Atlantic a good many million times since Columbus made his trip, but a little while ago the sea swallowed at one gulp the biggest ship ever made.

Human knowledge is a mighty curious thing. It is continually taking on something new at one end but, while doing so, is letting go something old at the other.

Nothing is too new to be impossible or so old as to be certain. Don't refuse the new just because it is new nor cling to the old just because it is old.

A closed house gets mighty musty, but a house without a roof soon goes to decay. Keep your mind open but keep something in it.

Open the doors and the windows once in a while and give the sunlight a chance, but don't tear down the walls for the sake of ventilation and so let the wind blow out your furniture.

Don't run ahead, but don't fall behind. Remember the calendar and try to keep up to date.

[*Hugh Molleson Foster, New York.*]

Testing Small Steam Turbines

By R. C. Allen

SYNOPSIS—How one manufacturer of small steam-turbines tests them and a description of the apparatus used, showing that the laboratory is fully equipped for doing the work. All turbines are fully tested before shipment, for governor adjustment and other details which can affect the satisfactory operation of the unit when installed in the power plant.

The increasing activities of power-plant engineers in investigating general station economics, and the tendency toward the adoption of steam turbine-driven auxiliaries in power plants, has led to investigations of the actual efficiencies guaranteed by steam-turbine manufacturers, as well as the institution of exacting tests to determine the merits of a particular machine before installation. The testing department, therefore, of a representative works must be more than the mere testing room, sufficient for the requirements of a few years ago; it must be a fully equipped laboratory as well, comprising all the necessary apparatus for testing generators, blowers, and for experimental work generally, in addition to regular performance tests of the turbines themselves.

One manufacturer of small turbines, the Terry Steam Turbine Co., has instituted a test department representative in every way, both as regards equipment and general organization. A general view is shown in Fig. 1. The following description of apparatus and general methods employed will undoubtedly prove interesting in general, as well as serve to indicate the thoroughness with which the characteristics of the machines manufactured are investigated before shipment.

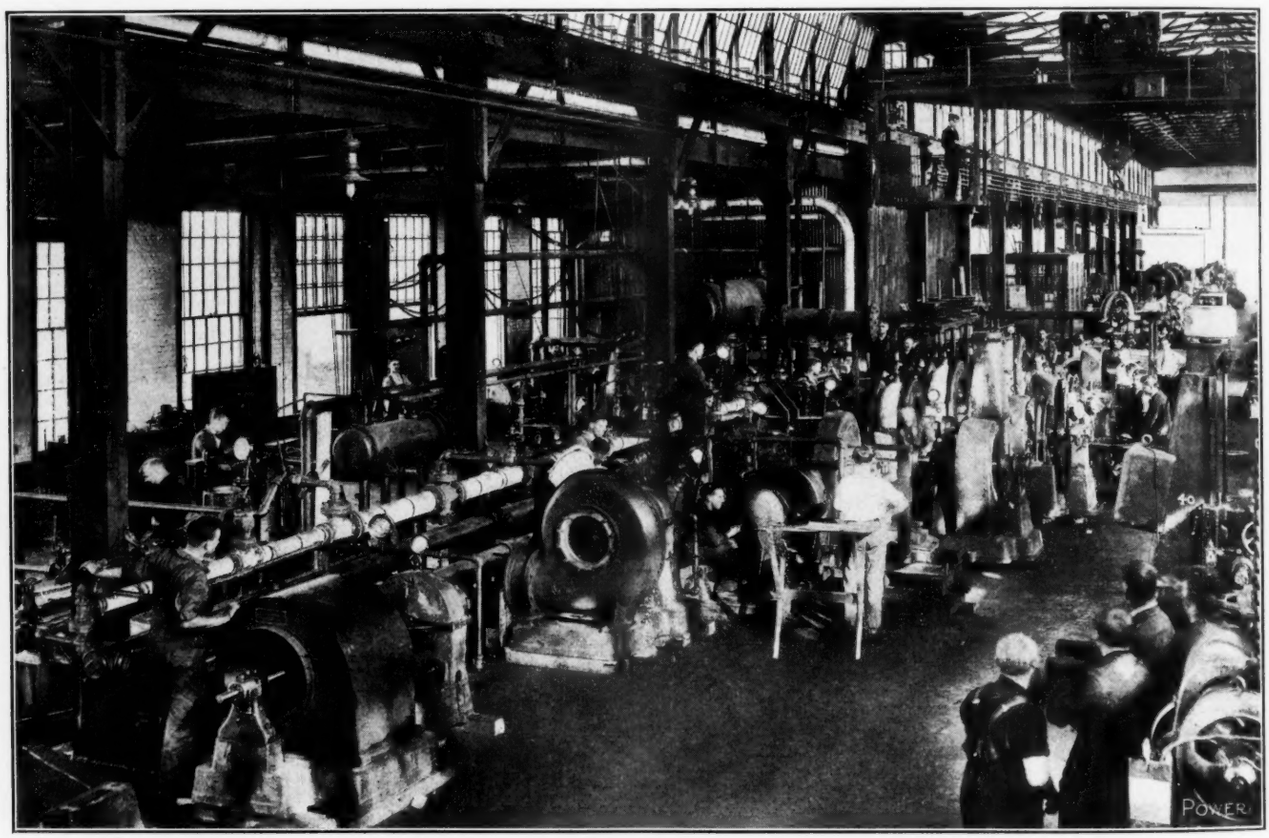


Fig. 1. General View of the Testing Department

Boiler Equipment

The boiler equipment consists of three vertical 500-hp. Manning boilers, a combined capacity sufficient for testing all machines at full load, or at loads sufficiently great that precise full-load conditions may be interpolated. The boilers are hand fired, and worked with either natural or induced draft, a good grade of semibituminous coal being used.

The boilers are connected to a common header, which is connected to the extra-heavy steel main-test line, placed about 4 ft. from the floor and fitted with numerous outlets, each provided with a throttle valve. The boilers, fittings and valves are designed for a normal working pressure of 200 lb.; the usual pressure maintained is about 150 lb. The higher pressures are used for testing turbines built under specifications requiring same. All power-plant auxiliaries exhaust into an open heater, a feed temperature of from 185 to 212 deg. being obtained.

Directly beneath the main steam-test line, which runs lengthwise through the center of the test floor, are two main exhaust lines, one being the plant-auxiliary exhaust line leading to a heater at practically atmospheric pres-

sure. The other line leads to the main condenser, and is used when water rates are required on condensing or noncondensing machines, or when any general tests are required on condensing machines. For each test connection in the high-pressure steam line, there is a corresponding opening in both the condensing and noncondensing exhaust lines, a simple form of connecting pipe and valve making it possible to couple a machine to either exhaust line as desired.

The main condenser is of the surface type, and of ample capacity to handle condensing machines up to 750 hp. capacity with a vacuum of 28 in. referred to 30-in. barometer.

A dry-air pump of unusual proportions takes care of the air leaks that are impossible to eliminate in temporary test piping.

Constant hotwell-level control is obtained by the usual method of a float-regulated steam valve, controlling a duplex pump, which discharges into a chute, which may be alternately directed into two tanks, mounted on separate standard weighing scales, the tanks being also fitted with the necessary outlet valves leading to drains. As the method of weighing surface-condenser discharge is generally considered the most satisfactory and indisputable means of determining the total steam consumption of any steam-driven prime mover, the greatest care is taken to maintain this equipment in the best possible condition, particularly with regard to water leaks around tube glands, as well as air leaks into the system.

Main Testing Apparatus

A complete secondary testing equipment is installed to handle machines of 50 hp., and below, running condensing or noncondensing.

Condensing Apparatus

The main Worthington condensing equipment is standard apparatus, which also includes a cooling tower, the circulating pump of which is driven by a 40-hp. Terry turbine; the fans, however, are driven by a 15-hp. motor, supplied with current from the factory mains. The testing apparatus for large turbines is shown in Fig. 2.

The secondary condensing equipment for smaller machines includes a small C. H. Wheeler surface condenser, hand-controlled hotwell pump, and separate dry-air pump, separate measuring tanks and scales being furnished, all similar to the main equipment, but on a smaller scale. The equipment for testing small turbines is shown in Figs. 3 and 4. Cooling water is bypassed from the main condenser circulating-pump discharge, the outgoing water leading to the cooling tower.

All steam gages used are periodically calibrated by a dead-weight gage tester. Important readings, such as nozzle-inlet pressures, are frequently taken by a number of gages connected to various points in the steam belt, thus eliminating possible chances of error in the instruments, as well as possible effect of local disturbances in the steam belt itself at points of measurement.

All electrical instruments used are also checked at intervals to insure their reliability.

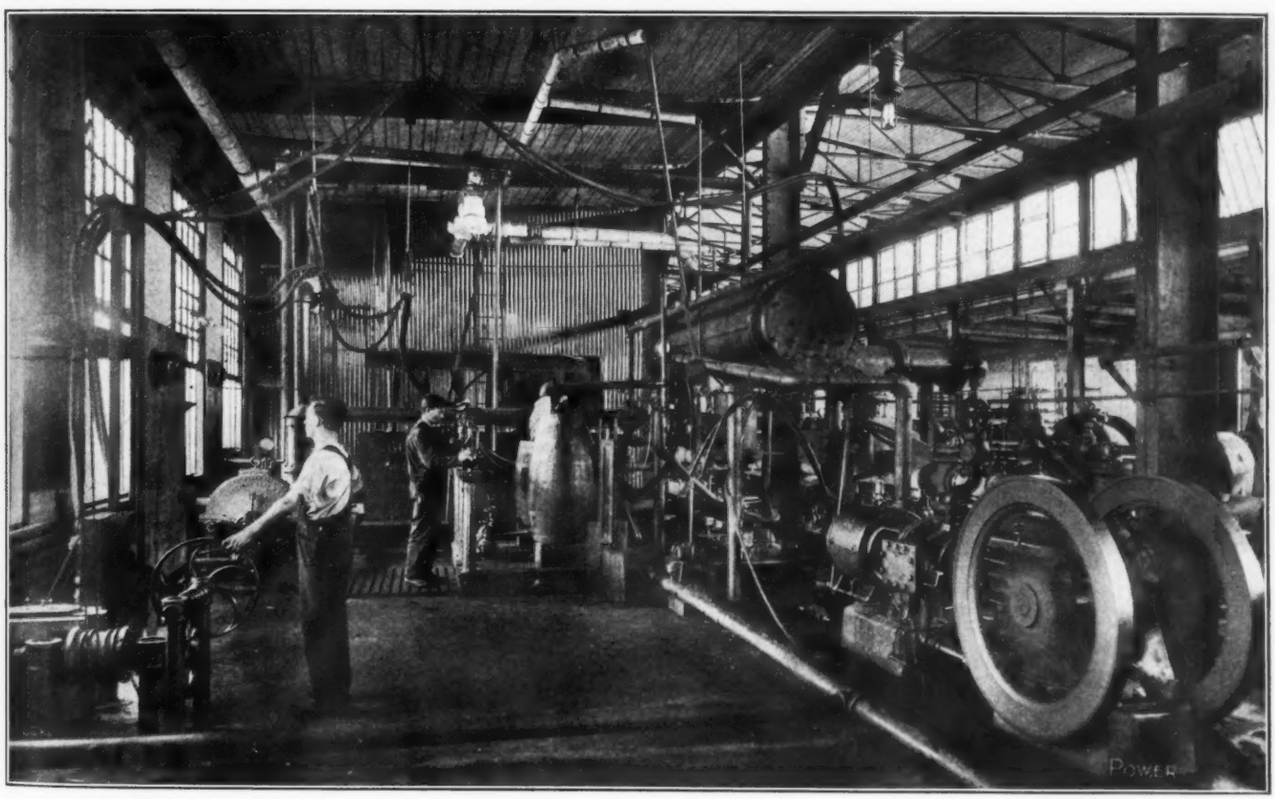


Fig. 2. Testing Department for Large Turbines

Testing

Final testing of all turbines before shipment consists of connecting the turbine to the proper steam and exhaust lines, adjusting the governor to no-load speed, adjusting the shaft glands, safety valve and the emergency governor, also the thrust clearance and proper location of the wheel with reference to the stationary element.

The turbine is then run for several hours after the final adjustments are made, the exact time depending on the judgment of the representative from the engineering department who finally releases the machine. Any indications of bearing or governor troubles, however, are sufficient to prolong the test, until satisfactory operation is obtained.

By this method, the machines are finally inspected by a representative of the engineering department who is a disinterested party in their manufacture, and who is in no way connected with their erection or testing, but is called upon in each particular case to act in the capacity of a customer inspecting his purchase.

The majority of test work consists of running complete tests for capacity and steam consumption, either

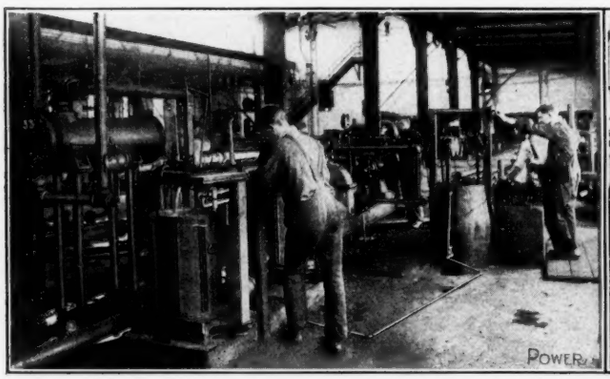


FIG. 3. TESTING SMALL TURBINES

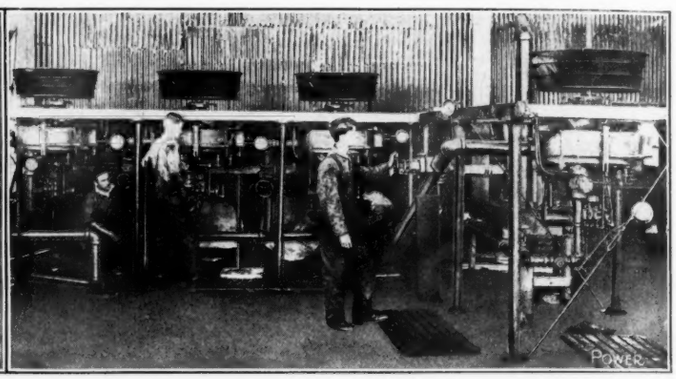


FIG. 4. TESTING VERTICAL UNITS

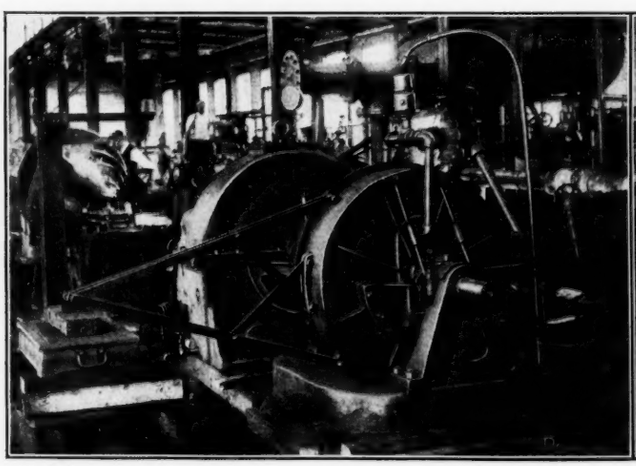


FIG. 5. NEAR VIEW OF WATER BRAKE

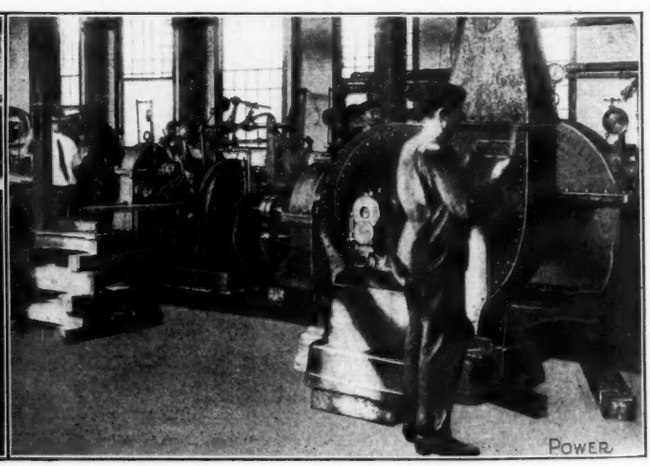


FIG. 6. TESTING BLOWER UNIT

for visiting engineers representing the purchaser, or to check up the characteristics of any particular turbine on account of the possible lack of data on its operating conditions, which may be unusual.

These turbines are connected to the main condenser (or the secondary condenser if below 50 hp.), exhaust line being fitted with mercury column and vacuum gage if the turbine is to run condensing and mercury manometer and compound gage if the machine is to run noncondensing a steam gage is fitted in the main steam line, and usually two or more gages between the governor valve and the nozzle inlets, viz., in the steam belt or steam "ring." Steam temperatures and calorimeter measurements are taken in the steam line immediately before the governor valve, the "Carpenter" type of throttling calorimeter being used.

The load is taken by either a prony brake or water brake, Fig. 5, according to the precise operating conditions. In the majority of cases one of the water brakes or familiar Webb dynamometer is used, consisting of a series of smooth disks (alternately revolving and stationary) inclosed in a casing mounted on ball-bearing trunnions, water being fed into the sides of the casing near the shaft, and discharged at the bottom of the same, Fig. 7. The main bearings are hung from the casing in order to include the bearing friction in the turning moment as recorded. The brake arm being mounted on the casing, the torque is measured by standard scales in the usual manner.

Several water brakes are used, each covering a definite range of speed and horsepower, the capacities overlapping sufficiently to have a brake available for every conceivable operating condition.

The test-floor equipment also includes similar prony brakes for running tests on turbines at speeds below the satisfactory operating range of the water brakes.

The speed is read by a tachometer belted to a brake shaft, as well as by either a portable hand tachometer or counter applied directly to the end of the shaft. The usual method of procedure is to first adjust the turbine governor to a speed, say, 10 to 20 per cent. higher than the normal speed. The required steam and exhaust conditions are then obtained and maintained constant

throughout the test by adjusting the throttle and exhaust valves, the load meanwhile being built up on the brake. When steam conditions are reached, the load on the brake is varied by throttling the inlet and discharge water until the desired speed is reached and maintained.

This method gives the least number of variables as well as permitting the absolutely constant steam flow through nozzles necessary for water-rate tests, which would not be the case if it was attempted to operate the machine on its own governor.

Steam readings, water and brake readings are taken for a reasonable period, say, from 30 to 60 min., after which time the steam pressure is lowered by hand, thus obtaining partial load conditions, and another test made.

Three or four points are thus taken which enable the characteristic curves of capacity, total steam, and water rate to be plotted.

From the results of a great number of tests, the total steam passed by standard designs of nozzles has been carefully checked with Napiers' simple formula:

$$W = \frac{P A}{70}$$

where

W = Pounds of steam per second passed by nozzles;
P = Absolute inlet pressure in pounds per sq.in.:
A = Total area of orifice in sq.in.

It was shown that it is possible to modify the constant 70 so as to bring the total water rate for particular designs of nozzles as calculated by this method within the limits of accuracy obtainable by actual measurement.

This method has been repeatedly verified by official tests, and has been found so reliable that it is employed in a great number of tests, thereby reducing the time required to conduct a test to a minimum.

In the majority of cases, generating sets are tested up to full load, water rheostats being used. The largest resistance consists of a series of alternate stationary and adjustable plates immersed in a salt-water bath, the adjustable plates being raised or lowered by a windlass adjacent to the test switchboard, it being possible to absorb direct-current loads up to about 3000 amperes.

With each generating set, complete records are made with reference to governor characteristics, steam-ring pressures at various loads (from which water rates may be calculated) as well as the characteristics of the generator itself, particularly with regard to the compounding of direct-current generators; also, the final heat-run temperatures.

In the case of blower units, the tests are usually in accordance with the type of service for which the blower is designed. Gas blowers are either tested by the cone method, taking pitot-tube velocity readings at the end of a tapered cone fitted to blower discharge, shown in Fig. 6, or by taking pitot-tube readings in a duct fitted to the blower outlet, the standard "Taylor" tube used for these latter tests.

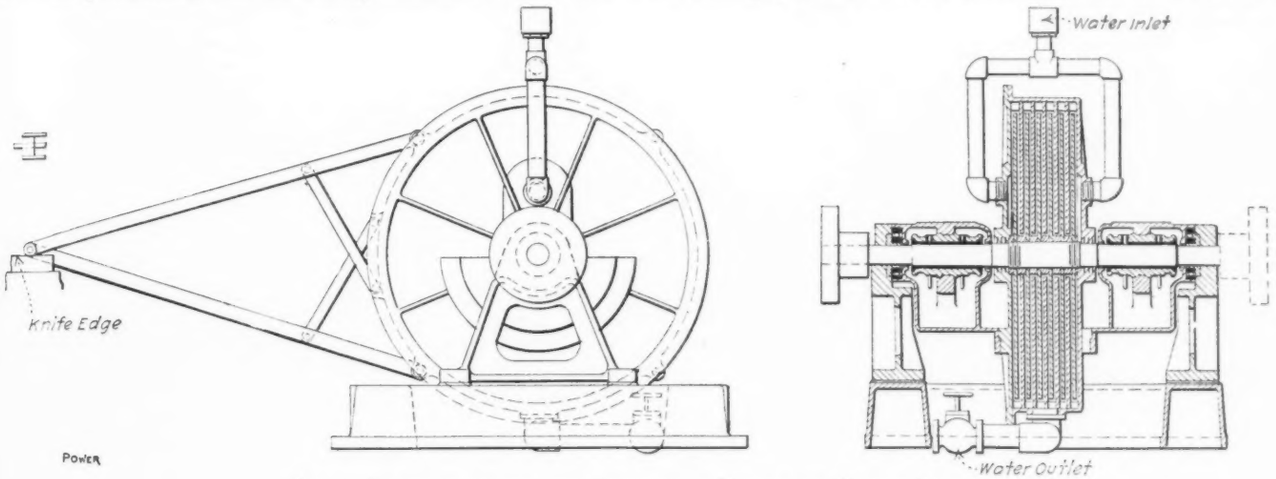


FIG. 7. DIAGRAMMATIC AND SECTIONAL VIEWS OF WATER BRAKE

For obtaining blower efficiency the turbine is first calibrated by running brake tests at various ring pressures as well as at various speeds and plotting these results in curve form. During the air tests, the speed and ring pressure being noted, for any particular delivery, the brake horsepower delivered may be interpolated directly from the calibration curves, and as the air horsepower can be calculated directly from the pressure and capacity readings, the blower efficiency may be directly determined.

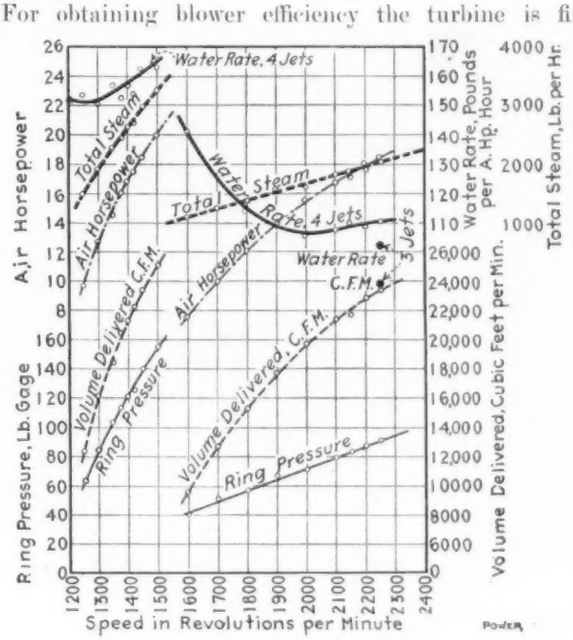


FIG. 8. TEST CURVES

Blowers or fans designed for discharge into a closed compartment are tested out by actually discharging them

into a suitable air-tight room, air readings for capacity being taken in the blower inlet, which is fitted with a tube of sufficient length to obtain parallel steam lines.

All test log sheets are in the form of loose leaves for loose-leaf notebook, which proves a convenient means of preserving data, either in shop tests or in tests made in outside power plants.

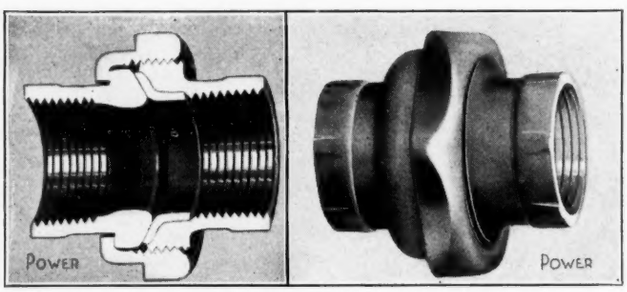
The final test report is made out on printed forms signed by the inspecting engineer, it being possible to easily copy by blueprinting without danger of error.

A set of test curves is shown in Fig. 8, illustrating methods used in graphically recording tests.

Mark Cold-Drawn Steel Union

This union is made seamless from cold-drawn, flat-strip steel. Each union is treated by a sherardizing process to render it immune from rust and corrosion. This process consists of heating the parts with zinc dust in a retort, which causes the zinc to penetrate a short way into the metal, and also leave an exterior coating. As the threads are cut before the treatment, they are also protected against corrosion without altering their sharpness and fit.

The Mark union, which is manufactured by the Mark



SECTIONAL AND EXTERIOR VIEW OF THE MARK UNION

Manufacturing Co., Chicago, Ill., consists of three main parts, male and female ends, which are joined by a coupling nut. A brass-ring seat fits between the coupling ends, as shown. The union is threaded to Briggs standard for pipe threads, and carries the same taper as the pipe. The expansion and contraction of the union under heat or cold is practically the same as the pipe.

Boiler-Efficiency Chart

BY JOHN C. PARKER

The chart herewith shown will be useful in connection with tests for determining the efficiencies of boilers at all ratings between banked fires and full capacity, and for calculating the results of individual boiler tests.

From the ordinary boiler-test data (gage pressure, feed-water temperature, actual water and fuel per hour and heat value of fuel) the equivalent evaporation per hour and per pound of fuel, horsepower and efficiency can be read direct from the chart with sufficient accuracy for ordinary use. The chart is especially valuable as a check on the calculations of boiler tests and serves to show up improbable results.

The moisture in the steam should be deducted from the quantity of water, or in case of superheat an equivalent allowance should be made in the quantity or temperature of the feed water. When the quantities are beyond the range of the chart, take one-half, one-quarter or one-tenth as the case demands, and for horsepower multiply by the same factor.

The fuel quantity can be in terms of fuel as fired, dry fuel or combustible. The heat value of the fuel must be taken on the same basis. The following problem is worked out with Fig. 1 as a key:

Test data:

Gage pressure, 150 lb. per sq.in.
Feed-water temperature, 62 deg. F.
Actual dry steam per hour, 10,000 lb.
Coal per hour, 1200 lb.
Heat in 1 lb. of coal, 13,863 B.t.u.

The dotted lines and arrows shown on the key indicate a simple method of procedure. Starting at the pressure scale (150 lb.), move horizontally to the equivalent feed-water temperature line (62 deg.), thence vertically down to the actual water evaporated per hour (10,000 lb.), thence horizontally to the water scale at the left and return along the inclined water line to the same ordinate. Here read the equivalent evaporation per hour (12,000 lb.). Move horizontally to the fuel per hour (1200 lb.), thence along the evaporation radial (10 lb.) to the B.t.u. (13,863) and vertically upward to the efficiency scale (70 per cent.).

By reading the 10,000 lb. horizontal water line as 1.0000 and 0.10000 for each thousand pounds above it, the factors of evaporation are found along the inclined

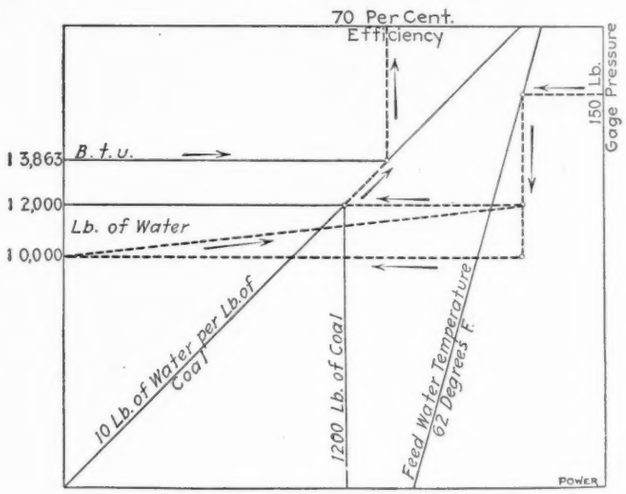


FIG. 1. KEY TO CHART

equivalent water line which starts from the same point on the water scale. To find a factor, move vertically from the pressure- and feed-temperature intersection to the 10,000-lb. horizontal water line, and that portion of the ordinate between this and the corresponding inclined line represents the decimal part of the factor for those conditions. In the foregoing problem the factor is 1.2000.

The dotted curve is assumed to illustrate the characteristic trend of normal efficiency curves from banked fires to full capacity. Three curves are combined in it: 1. The water curve with uniform increase in combustion; 2. The fuel curve with uniform increase in capacity; 3. The economy curve at all ratings. The complicated operation of normalizing separate fuel, water and efficiency curves and making them agree is thus avoided.

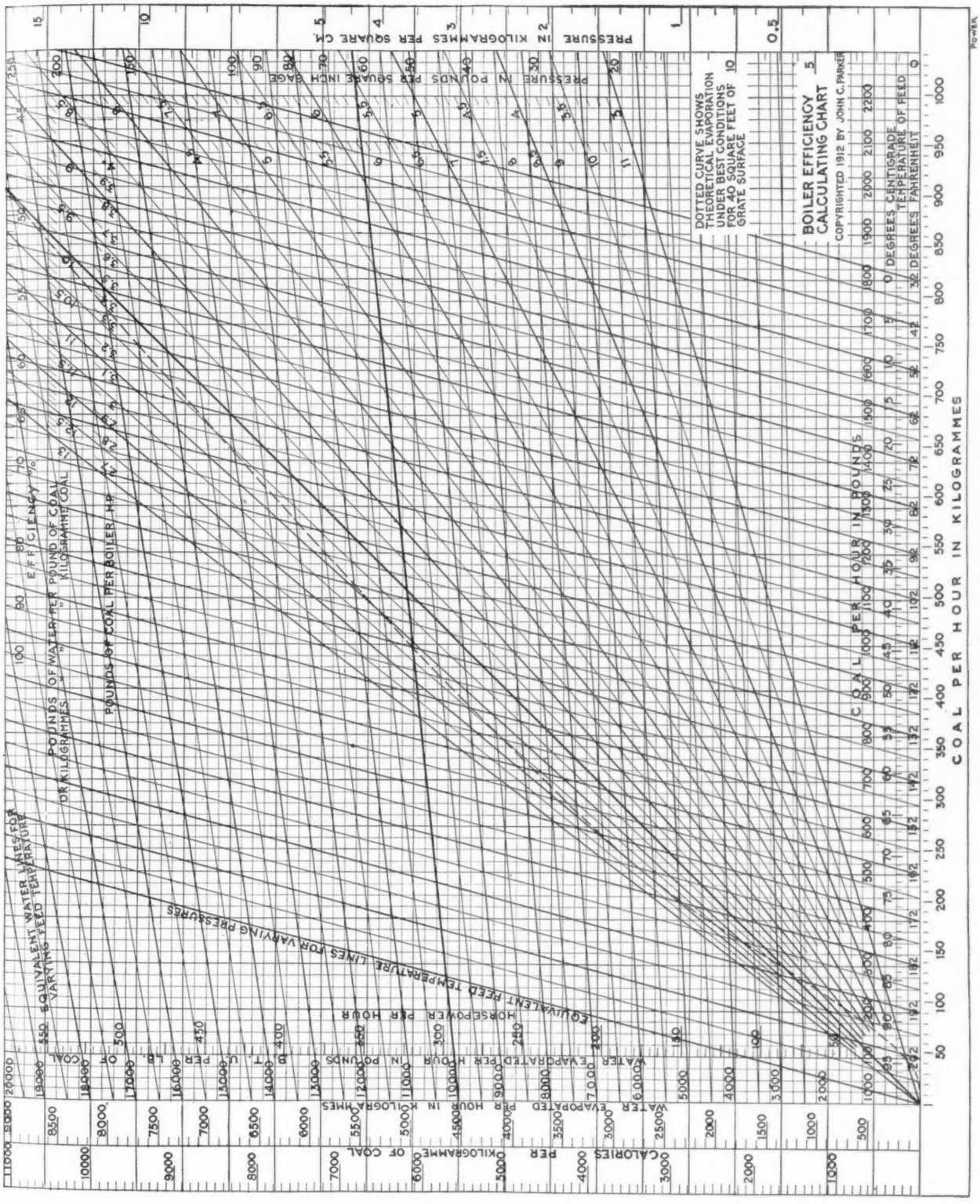

BOILER EFFICIENCY CALCULATING CHART
COPYRIGHTED 1912 BY JOHN C. PARKER
DOTTED CURVE SHOWS THEORETICAL EVAPORATION UNDER BEST CONDITIONS FOR 40 SQUARE FEET OF GRATE SURFACE
COAL PER HOUR IN POUNDS
COAL PER HOUR IN KILOGRAMMES
DEGREES CENTIGRADE TEMPERATURE OF FEED
DEGREES FAHRENHEIT
EFFICIENCY %
POUNDS OF WATER PER POUND OF COAL
OR KILOGRAMMES
POUNDS OF COAL PER B.H.P.
KILOGRAMMES
EQUIVALENT WATER VARIES FOR VARYING FEED TEMPERATURE
EQUIVALENT FEED TEMPERATURE LINES FOR VARYING PRESSURES
HORSEPOWER PER HOUR
WATER EVAPORATED PER HOUR IN POUNDS
WATER EVAPORATED PER HOUR IN KILOGRAMMES
PRESSURE IN POUNDS PER SQUARE INCH GAGE
PRESSURE IN KILOGRAMMES PER SQUARE C.M.
CALORIES PER KILOGRAMME OF COAL

FIG. 2. PARKER BOILER EFFICIENCY CHART

The normal efficiency curve shows the most economical rating and furnishes the necessary data for estimating the variable-load fuel consumption for normal operating conditions. It is also a valuable guide to economical operation from which the proper number of boilers to carry a given load can be ascertained.

The metric scales outside the main chart have nothing to do with its ordinary use. They are added for convenient comparison of foreign boiler-test results with our own. The scales can also be used as conversion tables for Centigrade and Fahrenheit temperatures, also for kilograms and pounds.

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The San Joaquin Light & Power Corporation has arranged with the J. G. White Engineering Corporation for the engineering and construction of a 6000-kv.a. hydro-electric plant on the Tule River, near Springville, Calif., for the installation of a 3000-kv.a. generator at San Joaquin power house No. 2, a 3750 kv.a. generator and waterwheel at Kern River Cañon Plant, the installation of a 6250-kw. steam turbine, boilers and auxiliaries and buildings at the Bakersfield steam plant, and the installation of four 666-kv.a. transformers.

Vertical-Lift Furnace Doors

SYNOPSIS—The design and operation of vertical-lift furnace doors are described herein. They are desirable on the furnaces of water-tube boilers, owing to the frequency of bursting tubes, as they safeguard the firemen against acident to some extent.

Danger of injury to firemen, due to the blowing open of furnace doors when a tube bursts, as pointed out in a recent editorial, has been reduced by the adoption of vertical-lift or swing type of furnace doors.

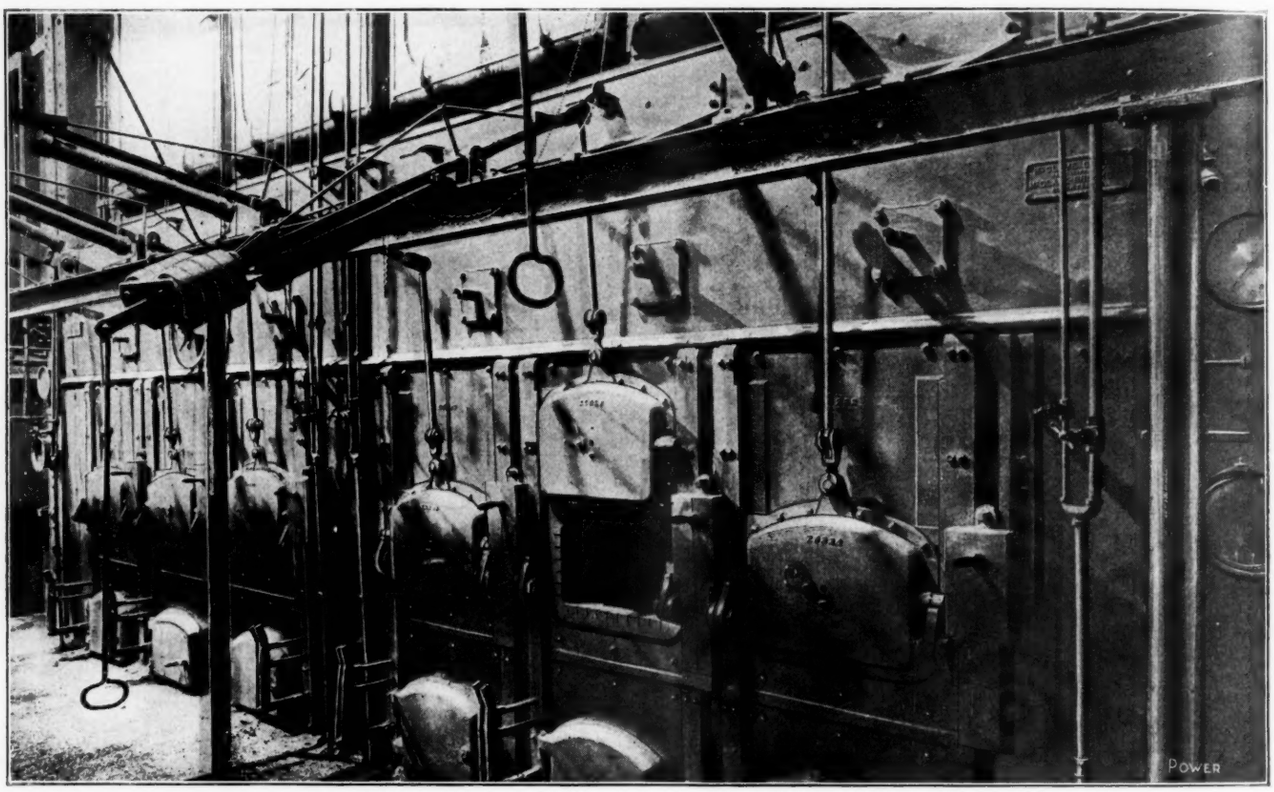


FIG. 1. ARRANGEMENT OF VERTICAL-LIFT DOORS AT HUDSON & MANHATTAN POWER HOUSE

An installation of the vertical-lift type is shown in Fig. 1. This arrangement of furnace doors is in the power plant of the Hudson & Manhattan R.R. Co., Jersey City, N. J., and was installed by the McClave-Brooks Co.

An examination of the illustration shows the operation of the doors. The lift doors run in guide plates attached to the furnace front. An I-beam is supported on iron columns and braced by iron arms attached to the boiler fronts. This I-beam supports the operating lever that is hung on a pin. At the outer end of the lift lever a number of weights, balancing the furnace door, are held in place by clamping plates. A tube, capped at both ends and partly filled with mercury is attached to the under side of the weight arm. On the outer end of the weight arm a hand rod is hooked and extends to within reach of the firemen. At the other end of the weight arm a link connects it with the lift door. The illustration shows the lift doors opened and closed.

To open the door the firemen pulls down on the hand rod. The mercury in the cylinder runs to the lower end of the tube as soon as it has passed a horizontal position.

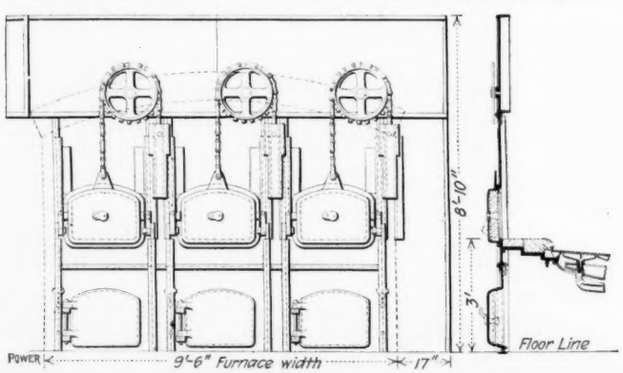


FIG. 2. COUNTER-WEIGHTED VERTICAL-LIFT DOORS

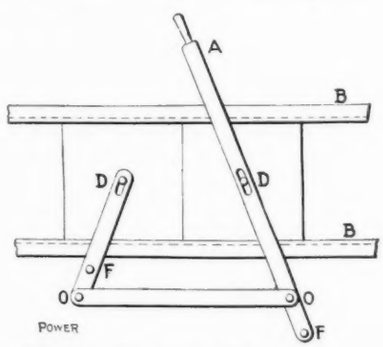


FIG. 3. ENGLISH TYPE OF LOCOMOTIVE FURNACE DOOR

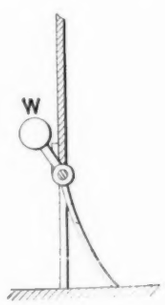


FIG. 4. OLD ENGLISH SWING DOOR

As the counterweight balances the weight of the door and link connection, the additional weight of the mercury keeps the door open until the fireman pushes up on the hand rod and closes the door. The mercury then runs to the opposite end of the cylinder and overbalances the counterweights. The doors are locked shut by the lugs shown on each side of the door, and which lock over the projection on each side of the door.

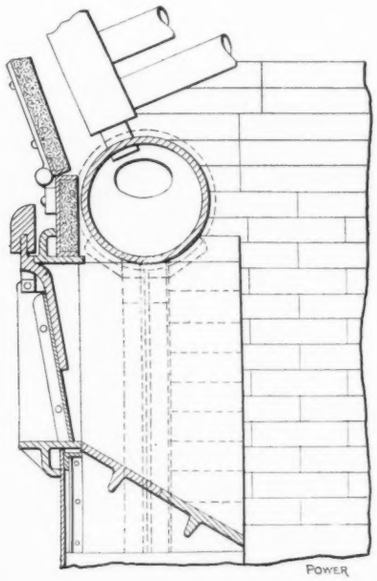


FIG. 5. FURNACE DOOR OPENING INWARDLY

A similar door, but operated by counterweights is shown in Fig. 2.

An English locomotive type of fire-door is shown in Fig. 3. A handle *A* serves, by a lateral pull, to open the two sliding doors of the furnace. The door when closed is an effective preventer of any flame outburst and, in a modified form, could be applied to the fronts of stationary boilers. An equal movement of the two halves of the door is secured by pivoting at a point, such as *F*. The curvature of the movement at *D* is taken care of by a slot.

A door long used in England is a thin curved iron door, Fig. 4. A weighted lever *W* balances the door, which works stiff enough at any position to resist the pull of the draft, but not so stiff as to prevent its being closed in the event of an explosion in the furnace. As the door can be left slightly open after firing, air can be admitted above the fire, as desired.

Another type of furnace door, made by James Beggs & Co., which cannot blow open if a tube should burst, is illustrated in Fig. 5. It is hinged at the top by a hinge pin which is bolted to the front of the cast-iron fire-door. The hinge pin hangs in bearing bosses on the boiler front. The door is lined with $\frac{3}{16}$-in. steel plate.

A counterweight extends across the furnace door. When the door is tilted inward, the counterweight is moved beyond the center line of gravity and holds the door in a horizontal position out of the way of the firemen. When the door is closed the bottom edge strikes the dead plate before the door reaches a vertical position, leaving the door at an angle of about 82 deg. If a tube bursts the force of the steam and water is exerted against the door tending to close it still tighter.

No door is a protection against furnace explosions when open, while firing, but those shown would be a valuable safeguard.

Elastic Corrugated Piping

Recently a process of manufacturing corrugated tubes has been patented, by which either standard wrought-iron or steel tubes can be corrugated by the Maciejewski process, as it is known. According to the pressure and size required, small- and medium-size tubes are made from ordinary steel tubing; for large diameters, lap-welded and rerolled tubes are used.

The corrugations are made by a method of pressing the material together, a special patented machine being employed. The process shortens the tubes as the corrugations are pressed into them, at equal distances apart, but without decreasing the original inside diameter, and the thickness remains uniform and is the same as in the original tube.

During the process of corrugating, any defects in the material at once become apparent. Interesting examples of corrugated tubes are shown in Fig. 1. They can be made in sizes from 1⅜ in. up to 18 in., including diameters suitable for use in boilers. Here the average length is about 12 ft., although any other length can be manufactured if required. The tubes for very long lines can be partly corrugated.

In steam-pipe lines, contraction and expansion caused

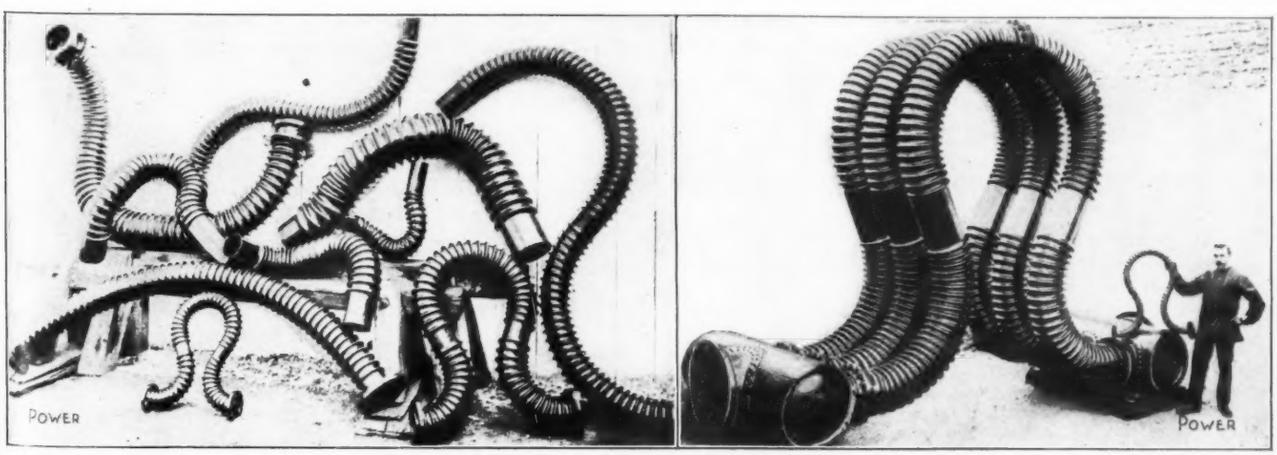


FIG. 1. EXAMPLES OF CORRUGATED TUBING

by the steam, vibrations of the engines, pumps and other units are effectively taken care of by the elastic property of the tubes. In fire-tube boilers, a greater heating surface is secured, and the strain removed to a large extent from the tube sheets and the combustion chamber. In superheaters, the heating surface is increased and in radiators for steam- and for hot-water heating systems, owing to the large outside surface, more heat is given off than with ordinary straight pipes, consequently smaller radiators can be used.

Another advantage is where the space for expansion and contraction is limited and large bends cannot be made. When steam is turned on or off there is a wide variation in the temperature; hence there is considerable linear movement in the line and its branches to the various units. This movement is easily taken up by a length of this corrugated pipe.

On account of the easy bending properties of corrugated tubes very small radii can be obtained having a large amount of elasticity. For instance, a smooth pipe 10 in. in diameter, having a height of 108 in. and a 108-in. throat, has a maximum expansion of 2 in. A corrugated tube of the same diameter but only 63 in. high and a 55-in. throat, has an expansion of 5½ in. Hence a pipe line having an expansion of 5½ in. would require three

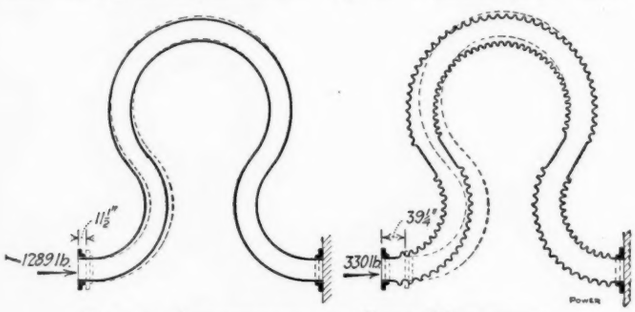


FIG. 2. DIFFERENCE IN PIPE MOVEMENT

bends of smooth pipe with a combined length of about 81 ft., or only one corrugated tube 12 ft. long.

In Fig. 2 an ordinary 6-in. pipe is shown, bent in the shape of a loop, one end being fixed and the other free to move.

When subjected to a lateral pressure of 1289 lb. the axial movement was 11½ in. A corrugated pipe of the same size and thickness was bent and fastened as the plain pipe; on applying 330 lb. pressure there was an axial movement of 39¼ in., or over three times that of the smooth pipe.

The process for making this corrugated pipe is patented in Europe and the United States by N. Maciejewski. The pipe is being made in Russia, Germany, Belgium and France. The United States patents are for sale by Schuchart & Schutte, 90 West St., New York City.

❖

The coal-production figures of 1912 are being compiled as rapidly as possible, and from reports already received it appears that the total output of Alabama mines will be well over 18,000,000 tons, which is approximately a 21 per cent. increase over 1911. This abnormal increase in coal consumption bespeaks the wonderful industrial progress now being made in Alabama and adjacent states. Many new mines are being opened with the expectation of getting a goodly supply of the coal business that will naturally develop in connection with the Panama Canal trade. If adequate shipping facilities are furnished, the year of 1913 will show a substantial increase over last year.—"Coal Age."

The Flow of Steam through Pipes

BY H. V. CARPENTER*

Judging from the comments I have received since the publication of the charts representing the flow of steam (POWER, Dec. 17, 1912, page 889), it appears that the following charts covering much lower pressures and larger pipes may be of interest: The charts now given cover pressures from 0.4 in. of mercury, absolute pressure, up to 25 lb. per sq.in. absolute, and pipe sizes from 2 to 60 in. in diameter; while those previously published covered pressures from 6 to 500 lb. per sq.in. and pipes from 1 to 20 in. in diameter.

The original experiments do not give sufficient data to warrant the use of the formulas over as wide a range as is covered by the charts shown here, but the results seem to check quite well with practice so they can perhaps be accepted as representing the truth as closely as is possible at present.

As before, the method of reading the charts is shown by the heavy dotted lines; for example, following the dotted lines on the velocity chart, it is found that if the loss of pressure is assumed to be 1 lb. per 100 ft. of pipe, in a 12-in. pipe, and the absolute pressure is 5 lb. per sq.in. at the middle of the pipe line, then the velocity of the steam will be a little over 41,000 ft. per min.; or, if the pressure is 3 in. of mercury the velocity will be nearly 74,000 ft. per min.

In a similar way the quantity chart shows that, with a drop of 1 lb. per 100 ft., in a 12-in. pipe, and an average pressure of 5 lb. per sq.in., the quantity of steam delivered will be 440 lb. per min.; or, if the pressure is 3 in. of mercury, 250 lb. per min. will be delivered; or, if the pressure is 1 in. of mercury, 150 lb. will be delivered.

The charts may, of course, be worked in any direction so that if any three of the quantities are known or assumed the fourth may be determined.

It will be noted that by using both charts for the same case the velocity required to deliver a given quantity of steam per minute may be determined; for example, in the first case given above it follows from the results obtained with both charts that to deliver 440 lb. of steam per min. through a 12-in. pipe at an average pressure of 5 lb. absolute, a velocity of 41,000 ft. per min. will be required.

All of the charts are calculated for saturated steam. There should be little error, however, in their use, for superheated steam provided that instead of the actual pressure of the superheated steam we use the pressure at which saturated steam has the same weight per cubic foot.

In the calculation of the charts it has been assumed that the nominal diameter of the pipe is its actual diameter. The error due to this will not be noticeable, except, perhaps, for piping over 12 in. in diameter, which is rated by its outside diameter. In these larger sizes the actual inside diameter should be used in applying the charts.

If it should be desired to apply the charts to pipes which are not circular in cross-section, it would be necessary to calculate the hydraulic radius (cross-section divided by perimeter) of the conductor. This multiplied by four would be the equivalent diameter.

The enormous velocities which the velocity chart shows to be permissible at low pressures emphasize the need of avoiding sudden bends or offsets in condenser piping.

*Professor of mechanical and electrical engineering, State College of Washington.

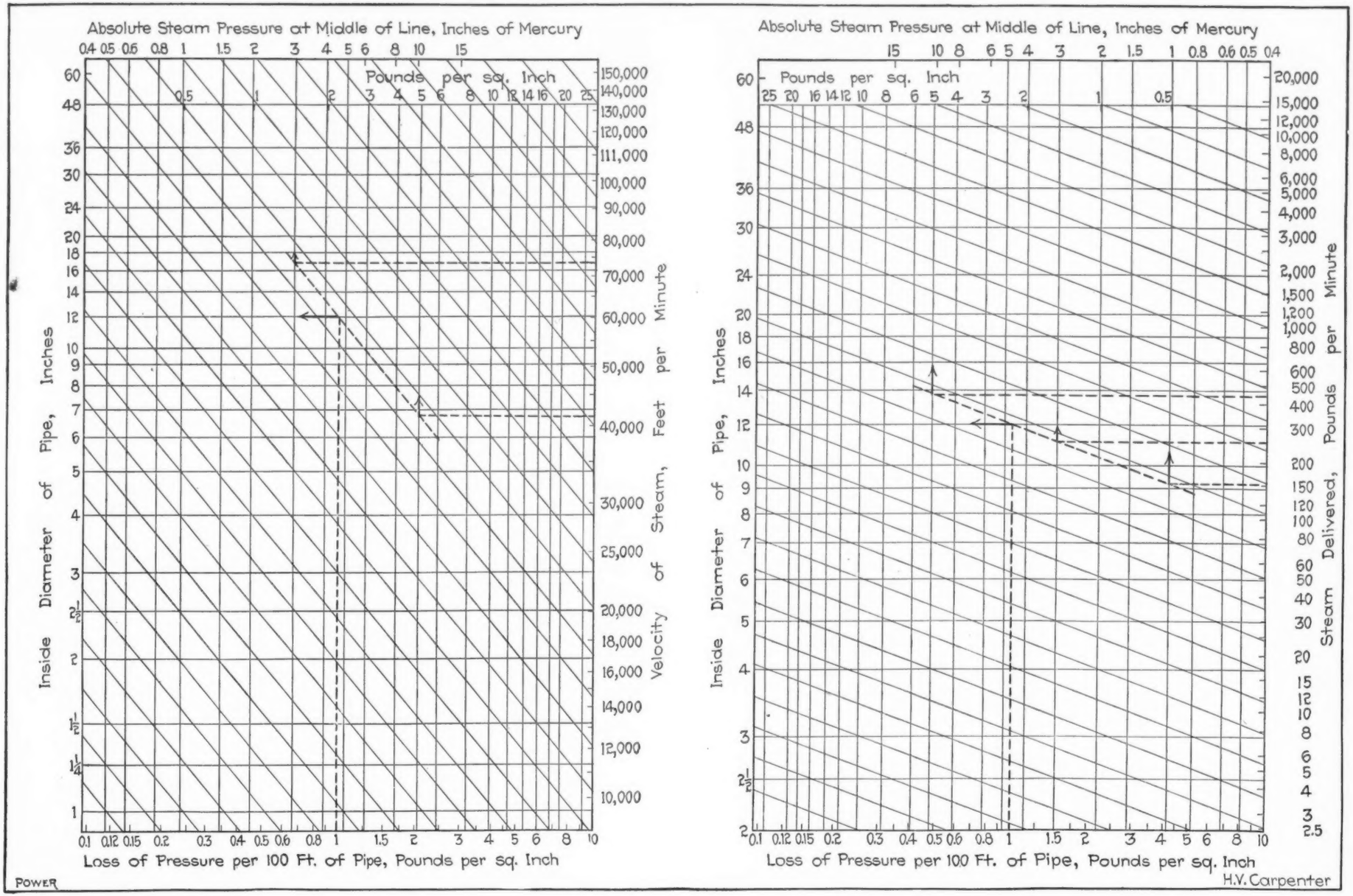

Absolute Steam Pressure at Middle of Line, Inches of Mercury
Pounds per sq. Inch
Inside Diameter of Pipe, Inches
Velocity of Steam, Feet per Minute
Loss of Pressure per 100 Ft. of Pipe, Pounds per sq. Inch
POWER
Absolute Steam Pressure at Middle of Line, Inches of Mercury
Pounds per sq. Inch
Inside Diameter of Pipe, Inches
Steam Delivered, Pounds per Minute
Loss of Pressure per 100 Ft. of Pipe, Pounds per sq. Inch
H.V. Carpenter

CHART SHOWING LOSS OF PRESSURE OF STEAM CORRESPONDING TO GIVEN PIPE SIZE, PRESSURE AND VELOCITY

CHART SHOWING LOSS OF PRESSURE OF STEAM CORRESPONDING TO GIVEN PIPE SIZE, PRESSURE AND AMOUNT DELIVERED PER MINUTE

ELECTRICAL DEPARTMENT

Sparking

By E. F. Butler

In the operation of electrical machinery and particularly in the case of direct-current generators and motors the fault most commonly met with is sparking at the brushes. There are in all about thirty causes for sparking, a number of which are due to faulty design or errors in erection. These will not be considered here, but instead, only those classed as operating faults. The following remarks apply only to machines fitted with carbon brushes as these are in the majority.

Probably the most frequent cause of sparking is overloading. An ammeter in circuit is the most reliable guide to this. The sparks from an overload are bluish white and extend the whole width of the brush. All the brushes, as a rule, sparking equally. If the overload be increased the sparks will get longer and longer until an arc is set up from holder to holder. This is known as a "flash-over" and in the case of a motor may burn the brush gear and damage the armature. In a generator it will

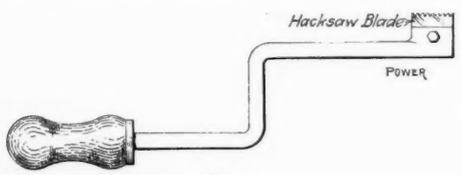


Fig. 1

have the effect of short-circuiting the armature. Usually no damage will result electrically as this will destroy the magnetism of the fields and so bring the voltage down to zero, but a sudden and severe strain is put upon the driving end of the machine. The remedy is, of course, to find and remove the cause of the overload.

Another common cause of sparking is high or low segments or mica. As the brushes pass the faulty places they jump and partially break the circuit, this results in flashing or arcing, and the faulty bar and those near it will be rough and blackened.

Very little can be done with bad segments except to change them. In the case of high bars of mica, take out the armature and turn up the commutator in a lathe, first wrapping the winding near the commutator to prevent turnings getting in and lodging at the back of the commutator. After this has been done make a tool as shown in Fig. 1 and recess the mica $\frac{1}{32}$ to $\frac{3}{64}$ in.

The cranked shape is useful for getting at a commutator without removing the armature. Oily or dirty commutators are also a common cause of sparking and here the remedy is usually obvious. Points to note in machines which have a tendency to throw oil are that the oil grooves do not extend right through to the inner edge of the bearing, that the overflow is not choked up, and also that the oil is not too thin at the highest temperature of the machine.

Vibration, more especially in motors, is a common cause of sparking. It may originate either in the machine or from some external source. First examine the pole-pieces to see if they are tight; also the foundation bolts. Note if the bearings are worn; if so, they are likely to rattle. See if the shaft is bent or sprung. Moreover, a pinion too deep in the gear or badly worn may cause the vibration. Rawhide or paper pinions sometimes work along the shaft and run on the metal shrouding. In the case of belts flapping, bad joints should be looked for. Try the armature for endplay; if this is excessive, turn a washer, preferably of brass, of such thickness as to leave about $\frac{1}{32}$-in. endplay. Place this on one end of the shaft so as to bring the brushes about central on the commutator.

Excessive vibration will often cause the coils to break near where they are soldered to the commutator. Sparking due to such an open circuit in the armature cannot very well be mistaken. It is a vicious green, due to the arc set up between two adjacent segments, and shows itself as a ring of fire often extending all round the armature. On stopping the machine the burnt portion is very evident. In a four-pole machine it will be noticed that two places are marked, although there may be only one break. If the disconnected end of the coil can be seen it can often be repaired at once with a soldering iron. When a temporary repair is necessary to keep the machine going, bridge the burnt segments. If it is a four-pole machine start up and watch closely to see if it smells or smokes. If it does, then the wrong pair has been bridged. Clean them out and scrape the mica between them until it shows clear, then bridge the other pair of burnt-out segments and when making the repair permanent, do not forget to clean them.

Of the purely electrical causes of sparking the most common is the wrong position of the brushes. Frequently the brush gear is insecurely clamped and it works around into the wrong position. The writer recalls a case of a four-pole shunt machine of 15 hp., which on test at full load was observed to spark badly at one set of brushes, while the other three were all right. On moving the rocker the sparking at this set disappeared, but the other three sets started sparking. After an inspection had been made, a band of paper was pasted around the commutator and divided off equally into four parts; it was found that one set of brushes was not diametrically opposite the other, the rocker casting being at fault.

Faulty field coils are another cause of sparking. Sometimes oil in the bottom of the motor case will rot the insulation and either ground or partially short-circuit them. With faulty field coils, in addition to sparking, the speed is often excessive and the motor does not start up well. This is often a clue to the trouble. If there is a ground on the field coils and one of the main leads is also grounded, either by accident or otherwise, the trouble may be located by feeling the coils and noting whether some of them are hot and others cold.

Brushes also spark, owing to too little tension or from too much tension. About 2 lb. per sq.in. is correct for most motors, although for traction and railway motors up to 6 lb. is sometimes necessary. Some brushes are copper-plated, and if they happen to wear so that the copper gets onto the commutator, sparking will be set up and the commutator will be roughened. Dirt and grease will cause the brushes to stick in the holders; also, if they are at all tight they are likely to swell when hot. If, on the other hand, they are too slack, they will wobble in the holder and become rounded at the end, and sparking will result because of insufficient contact with the commutator.

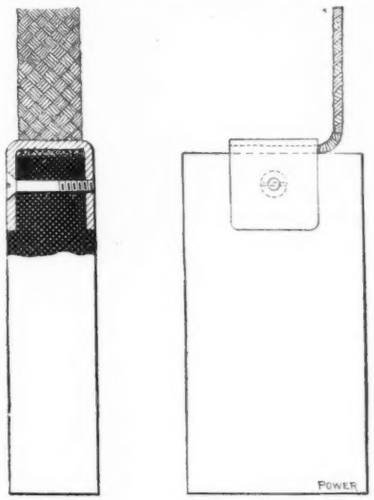


FIG. 2

A brush is right when it will just slide through the holder onto the commutator by its own weight. When many brushes are used it is cheaper to make a gage and reject those not of size. Too little tension is sometimes due to the springs becoming weakened by the current passing through them. This is usually due to bad design and every brush should be fitted with tags or pigtails to shunt the current from the springs.

A traction motor which not only burnt up springs, but two sets of holders in less than six months was cured in this way. The brushes were filed $\frac{3}{32}$ in. deep and $\frac{3}{4}$ in. down on both sides. A piece of $\frac{1}{16}$-in. strip copper was bent to form three sides of a square, fitted over the field portion of the brush, drilled and countersunk. A piece of dynamo flex was placed between the top of the brush and the strip, squeezed down and a bolt put through and fitted with a countersunk nut. To make all secure the end of the bolt was lightly riveted to keep the nut from working off. The other end of the flex was clamped under a setscrew tapped into the body of the brush-holder. The copper tip did not extend the whole width of the brush as the tension spring only pressed on the center. This gave room for the flex to be brought up alongside. Fig. 2 shows how this was done.

Liquid Rheostats for Large Alternating-Current Motors

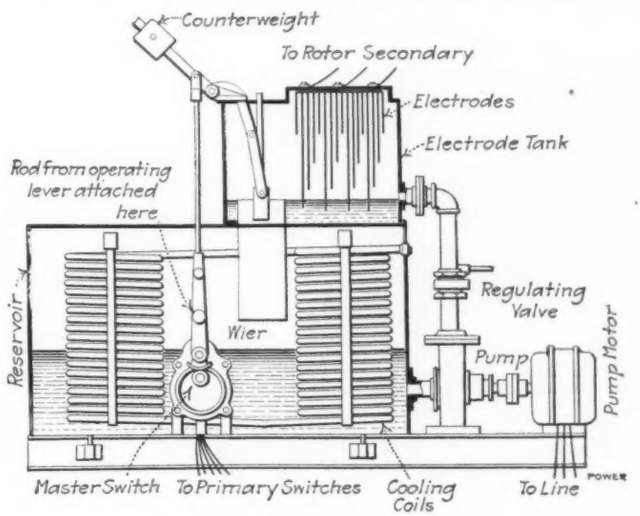
The use of large alternating-current slip-ring motors for driving mine hoists, winding gears, rolling mills, etc., has increased largely during the past few years and has created a demand for a simple, efficient and economical controller. To meet this demand the Westinghouse liquid rheostat has been developed.

These rheostats provide an infinite number of steps between the minimum and maximum limits, thus permitting the fine speed adjustments and very smooth acceleration.

The rheostat consists of two compartments, an upper tank for the electrodes, and a lower reservoir. The three phases of the rotor are connected to electrodes suspended in the upper tank. A small motor-driven pump pumps a steady stream of liquid, usually a solution of soda, from the reservoir into the electrode tank, and back into the reservoir over a weir. By raising or lowering the weir, the height of the liquid in the electrode tank is correspondingly varied. The resistance in the rotor circuit decreases as the liquid level rises, and *vice versa*, and the motor speed, of course, changes with the rotor resistance.

The primary circuit of the motor is closed and opened by means of electrically operated switches, which are controlled by a master switch mounted on the rheostat.

The operating lever of the rheostat controls both the master switch and the weir. When the lever is in its central, or off, position, the primary switches are open and the weir at its lowest level, so that the secondary resistance is a maximum. Moving the lever in one direction closes the proper primary switches for starting the motor forward and raises the weir. Moving the lever in the opposite direction reverses the motor and again raises the weir.



SECTION THROUGH RHEOSTAT

Speed control is secured by varying the position of the weir by moving the lever; the primary switches do not open until the lever is placed in the off position.

A valve in the intake pipe of the electrode tank regulates the rate at which the liquid is pumped in, so that no matter how quickly the operating lever is moved, the liquid can only rise at the rate for which the valve is adjusted, thus fixing the rate of acceleration. When the lever is returned to the off position, the weir drops and the liquid level promptly falls.

Cooling coils in the reservoir prevent rapid evaporation of the liquid.

These rheostats are made in capacities of from 400 to 1500 horsepower.

CORRESPONDENCE

Static Charges on Belts

In the Apr. 15 issue is a letter, by L. A. DeBlois, discussing static charges on belts. For nearly 16 years I have had to do with belts and have never known a case where static electricity in a belt could not be entirely cured by treatment with Cling-Surface. In one instance a belt driving a generator supplying current to arc lights in a large railroad shop produced a heavy static charge in spite of an attempt to ground it by means of chains dangling very close to the belt. After the first Cling-Surface treatment the chains were removed and the belt never again showed a static charge.

CHARLES F. CHASE.

Philadelphia, Penn.

Hollow Conductors

In the May 13 issue there is an article by Clifford B. Parliman entitled "Alternating-Current Conductors," which takes up what is known as "skin effect" and the way of overcoming it.

His description of the cause of skin effect is hardly what I have been taught to believe, and I should think that a more accurate statement would be to say that the sudden increase in the amount of current flowing in a conductor, from zero to a maximum, then down to zero, and then to a maximum in the other direction when alternating current is used, sets up counter electromotive forces due to the cutting of flux in the material. At the center of the conductor these counter electromotive forces are stronger than at the circumference so that it is harder for the currents to get started there. As a result the current is flowing at the outside for an appreciable time before it begins at the center and with a high-frequency current the reverse comes too soon for there to be much current in the center of the conductor at any time.

On account of the permeability of an iron wire, there is with it considerable skin effect, but with copper and aluminum the effect is very slight except when large conductors are used and the frequency is much higher than usual.

The heating mentioned by Mr. Parliman as taking place in solid conductors transmitting alternating current is no greater than would occur with direct current if the resistance of the conductor were increased in a proportion equal to the apparent resistance of the wire mentioned by him. The only result of the skin effect is to increase the resistance slightly due to the current not being at its maximum density in the center of the wire or bar.

The footnote to the article in question mentions "Foster's Handbook," and if the tables given there are consulted, it will be seen what a very little difference the skin effect will make in the apparent resistance of a wire with any of the usual frequencies and sizes of wire. Even with a No. 0000 wire, a large size for high-tension transmission, and 60 cycles, the apparent increase in resistance is less than one-half of 1 per cent. While the New York Edison Co. might be interested on account of the very large currents handled by it, yet the feeders are tapped off the busbars so that each part of the busbar carries but a small portion of the entire current generated at the station and as that current is generated at 25 cycles the apparent resistance will be much less than would be the case with a 60-cycle station.

Hollow busbars were used by the Philadelphia Edison Co. at least 12 years ago. In Philadelphia it was admitted that so far as the influence on the skin effect was concerned, they were not necessary, but that the use of copper tubing was preferable to wire because of its increased stiffness.

G. H. MCKELWAY.

Brooklyn, N. Y.

Care of Brushes

While boiling brushes in mineral oil or employing special self-lubricating brushes is undoubtedly a remedy for many troublesome commutators, still I question if it is always necessary to resort to these means. In most cases if the engineer will start off with a true and smooth commutator and properly fitted brushes, which require only a minimum tension on the springs, and will refrain from using patent dressings, but simply touch over the commutator occasionally with a piece of pure paraffin wax and then wipe with a clean rag, he will soon have a good brown surface and brushes requiring minimum attention.

Tension on the brushes should be set by the aid of a small spring balance, so that all the brushes will bear with an equal pressure. This refers especially to high-speed machines; the pressure will vary from about 8 to 10 oz. per sq.in. of brush surface in slow-speed machines up to 1¼ lb. in the high-speed types.

Moreover, the brushes should be of such a fit in the holders that they will freely slide up and down without rattling and on no account should the brush-holder be relied upon to conduct the current to or from the machine. The current must be cared for by flexible leads carefully fixed into the brush, if possible running the full width of the brush so as to prevent local heating.

EDWARD RUSSELL.

Rochdale, England.

Briquetted fuel manufacture in the United States is passing out of the experimental stage. The production in 1912 was 220,064 short tons, valued at $952,261. Of the 19 briquetting plants operating, seven used anthracite culm, nine bituminous slack, one carbon residue from gas manufactured from oil, one mixed anthracite culm and bituminous, and one used peat. One plant at Detroit and one plant at Philadelphia, constructed for utilizing coke breeze, were not operated in 1912, the abrasive action of the coke dust being so destructive of the molds and machinery that the plants have been shut down.

The quantity of raw material available for briquets is ample and obtainable at little cost. The briquetting cost is $1 to $1.25 per ton. Slack piles at many mines have sometimes been burned to prevent cumbering the ground. The 220,064 tons of briquets made in 1912 represent but a drop taken from the bucket of available material.—*Geological Survey's "Mineral Resources in 1912."*

GAS POWER DEPARTMENT

Operation of Gas Engines Using Blast-Furnace Gas*

By Charles C. Sampson

The operation of gas engines using blast-furnace gas includes several important factors outside the actual operation of the engines themselves. One of the most important of these is cleaning the gas. As delivered by the furnaces it contains normally from 3 to 10 gr. of dust per cu.ft., but at times of slips or other sudden changes in the furnace, it carries much more. For use in engines the gas must be cleaned to at least 0.02 gr., but even this figure is too high to satisfy the operating engineer since it is possible to clean the gas to 0.005 or 0.006 gr. per cu.ft. with great benefit to the engines.

The method of cleaning most used at present has three stages: (1) Dry cleaning to 1½ or 2 gr. per cu.ft., which is always done by the blast-furnace department; (2) primary washing in static washers to about 0.15 gr. per cu.ft.; and (3) dynamic or mechanical cleaning in highly developed machines to 0.015 or less. The last stages are usually handled by the gas-engine department.

Dry Cleaning

Dry cleaning is done in dry-dust catchers, the standard design being a vertical, cylindrical shell of large diameter into which the gas enters tangentially near the top and leaves through a vertical outlet pipe extending about two-thirds down from the top. These dust catchers remove the heavier particles of dust, but their efficiency is only about 80 per cent., as they are apt to pick up, or perhaps do not drop, the finer dust, which is carried on by the upward current of gas to the outlet.

Sudden changes in the direction of flow of the gas, as at water seals or other bends, are quite efficient in the removal of dust. In one case gas carrying about 5 gr. per cu.ft. passed through four sharp bends and reduced the dust content to 2 gr. per cu.ft. For this reason every part of the dry-gas main where such bends are necessary can be made to assist materially in cleaning the gas, if pockets and valves are provided, so that the dust can be conveniently removed.

Where long gas mains are necessary, they can be made to add to the cleaning of the gas by building them in successive lengths with sufficient rise and fall to allow the dust to settle in pockets at the bottom angles. If the gas for any reason moves slowly in a long main the loss of heat through the pipe will probably reduce the temperature below the dew point and thus condense some of the moisture and cause the deposit of wet dust, which adds greatly to the cleaning-plant labor. This is especially apt to occur where two or more groups of furnaces supply one washing plant; the gas from the one with the lower top pressure will move slowly, or even reverse its direction of flow at times, allowing excessive cooling and the resulting condensation. This condensation will begin when the temperature is reduced to 115 or 120 deg. F.

Primary Washers

The present primary washers (the first stage of wet cleaning) are of the static scrubber type and include all those in which the gas passes through a stationary shell without moving parts, the water for washing being supplied either in spray or sheets. The spray and hurdle, Mullen, baffle, and rain-type scrubbers come under this classification.

The spray and hurdle system is preferred on account of its better distribution of water, and since it is self-cleaning it needs inspection only after long periods of operation. In the rain or baffle types the gas is more apt to channel and travel up one side of the scrubber and the water down the other.

Two outlets at opposite sides of the top are better than one on account of the deflection of the water by the gas currents if only one is used. This is particularly true if the water is sprayed by falling on spray plates as the gas current may then be strong enough to blow the water clear of the plate and thus entirely lose its effect. Spray nozzles are not subject to this fault, but are not able to handle water that has much dirt in it without considerable attention.

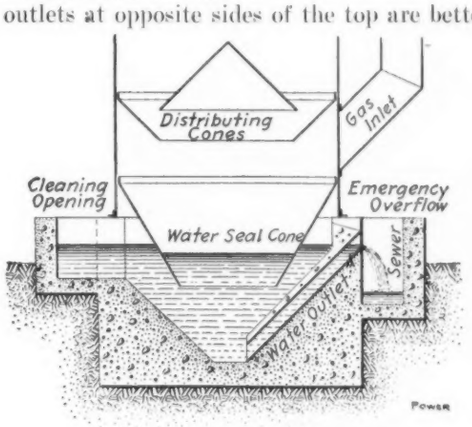


Fig. 1. Scrubber Bottom

In designing the scrubber bottom, its foundation and the basin and overflow for the outlet water, it must be remembered that while the usual working pressure will be from 6 in. to 18 in. of water, a slip will give pressure of from 40 in. to 50 in. for a short time. A normal head of water of 36 in. from the bottom of the scrubber to the water-overflow level with the basin walls 24 in. above this and an emergency overflow 4 in. below the top of the basin walls will care for slip pressures without blowing out any gas or overflowing the basin. Fig. 1 shows this arrangement of scrubber bottom.

Should the water-overflow pipe be stopped, the heavy mud will settle to the bottom, and when the overflow pipe is cleaned there will be such a quantity that even the extra head of water to the emergency overflow will not force it out. For this reason the forming of heavy chunks must

*Excerpts from a paper read before the American Society of Mechanical Engineers, May 21, 1913.

be prevented as much as possible and provision must be made for stirring the basin water both with hoes or rakes and with a stream of water.

Mechanical Scrubbers

The final stage in cleaning is done with mechanical scrubbers. These are highly developed and the Theisen patented gas washer has been in the lead for several years, although other types are now being worked out, their builders claiming better results with less water and power. The Theisen washers require about 3 per cent. of the power output, and from 16 to 18 gal. of water per 1000 cu.ft. of gas cleaned, which added to the 75 to 80 gal. required in the scrubbers makes the total from 90 to 100 gal. for the whole cleaning process. The newer apparatus claim to use about 20 gal. of water per 1000 cu.ft. of gas for the whole cleaning process.

Holders

In blast-furnace gas-engine plants the engines are entirely dependent upon the continuous supply of gas from the furnaces; a 100,000-cu.ft. capacity holder can only be

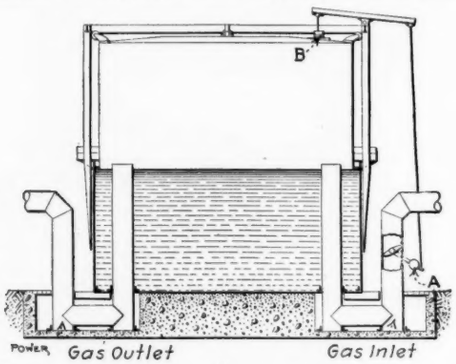


Fig. 2. Gas Holder with Regulating Valve

considered a pressure regulator with capacity for enough gas to allow retiring in good order when the gas supply is cut off for any reason. Thus in a 1000-kw. plant with such a holder the gas on hand would operate the plant only for about 25 to 30 min., and should not be counted on for more than 15 to 20 minutes.

The quantity of gas consumed by the engines is regulated by the governor to suit the power output, but since they must be supplied with gas at uniform pressure, it is necessary to regulate the gas supplied by some type of gasometer. This is best done by a gasometer of such capacity that the pressure fluctuations are not noticeable at the engines, and since it is well to have an emergency quantity of gas, the holder itself will meet both demands at once if supplied with an efficient regulating valve.

There should also be the possibility of regulating the gas quantity at the secondary washers since at times of very light loads the gas pressure between the holder and washer may blow out drip seals or cause dangerous gas leaks. This can be cared for by the installation of butterfly valves with quadrants either before or after the mechanical washers. The latter is to be preferred, for then the gas remains longer in the washers and receives additional cleaning.

A good regulating valve at the holder is a butterfly valve attached by means of levers and cables to the holder bell, so that it will remain wide open until the bell rises within a few feet of its upper position, and closes gradually until at the highest position it is completely closed. The arrangement shown in Fig. 2 works satisfactorily. The weight A must be heavy enough to close the valve, and the weight B must be heavy enough to open the valve and also lift the weight A.

All exposed water lines must be protected from freezing. This is especially true of the supply to seals, drips from the gas main, and any line that does not have a continuous flow. With good water separators after the secondary cleaning apparatus, freezing weather, or even 8 or 10 deg. F. below zero, will not cause trouble in the gas mains themselves, though any valves which may be nearly closed or which are closed part of the time must be carefully protected.

The water in the gas holder must also be warmed. The exhaust from the regulating valve coil will easily keep the holder water warm enough to prevent freezing, except in the coldest weather, when it is usually necessary to supply additional steam.

The holder water, if too hot, will charge the gas with water, so that condensation and freezing will take place in the supply pipes to the engine. When the water circulates properly in the holder it is not necessary to have it any warmer than 38 or 40 deg. F., while a rise to 65 or 70 deg. may give trouble.

Starting the Engines

Compressed air at from 150 to 200 lb. per sq.in. has proved satisfactory for starting gas engines. In a starting system of 2000 cu.ft. capacity the air pressure is lowered about 20 lb. in starting one 3000-kw. twin-tandem unit, and since 150-lb. pressure is sufficient for a start, there is a possibility of at least three starts from 200-lb. initial pressure. After the engine operator becomes familiar with the operating peculiarities of the engines he should be able to start them at intervals of from 4 to 8 min., and not lower the air pressure more than the compressor can make up in that time.

For the ordinary blast-furnace gas-engine plant of from three to six engines, two air compressors of 100-cu.ft. capacity and air-tank capacity of 2000 cu.ft. are sufficient, while for more than six engines the compressor capacity should be increased rather than the tank.

Lubrication

For general lubrication, such as main bearings, crosshead and crankpins and crosshead slides where the rubbing surfaces are at room temperature, an oil of the following physical characteristics gives excellent service.

Specific gravity	0.888
Viscosity (Tagliabue)	210 at 70 deg. F.
Cold test	35 deg. F.
Flash temperature	435 deg. F.

Because of the mixing of water from the cooling system with the oil, it is necessary to provide means for separating the water and oil in the filtration process, and this can be done thoroughly only by heating the oil to about 160 or 190 deg. F., and giving it time in a quiet condition to allow the separation. A large part of the dirt will settle with the water. Such that does not must be removed by filtration through fine cloth of organic fiber or through fine wire.

A good oil-cleaning system giving excellent satisfaction consists of one 1500-gal. water-separating tank, shown in Fig. 3, with a heating coil over which the oil flows as it enters on returning from the engines, and an

adjustable automatic water overflow to discharge the separated water, two settling tanks of the same size through which the oil passes in tandem to allow time for quiet settling of dirt particles, and a filter unit with 20 filter bags, 10 each in two filter tanks.

An extra tank is provided for use when either of the other three is out of service for cleaning. An auxiliary tank of about 200-gal. capacity is used for "boiling up" the sludge taken from either of the large tanks or the filters at the time of cleaning, as well as such dirty oil as can be drawn off daily from the overhead oil tank.

The varying cleanliness of the gas, hardness of cylinder walls and piston rings, piston speeds, mean effective and maximum pressures all have their influence on the action of the cylinder oil. An oil showing a specific gravity of

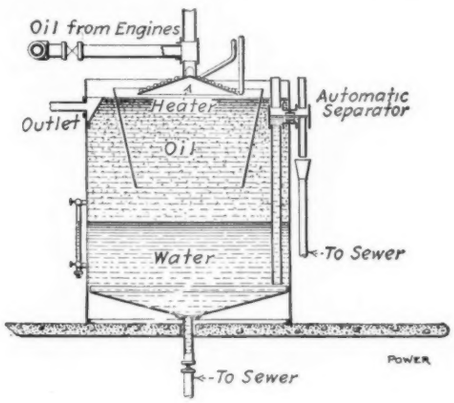


FIG. 3. WATER-SEPARATING TANK FOR OIL-CLEANING SYSTEM

0.902; viscosity (Tagliabue) of 78 at 212 deg. F., and a flash temperature of 380 deg. F, gave excellent results in a gas blowing-engine plant where the dust was low (0.01 or less), and the piston speed less than 600 ft. per min., but was not satisfactory in another, with 0.012 gr. of dust and a piston speed of 850 ft. per min. In the latter case the oil was replaced by one having a specific gravity of 0.920; viscosity, 203 at 212 deg. F.; and a flash temperature of 502.

IGNITION

The mechanically operated igniter is much to be preferred to the magnetic type. The current supply should be from a source not liable to fluctuation, such as that from a motor-generator set that supplies current to the ignition system alone and is arranged in connection with a storage battery, so that should anything happen to the motor generator the battery would take up the load, automatically signaling the operator.

Premature ignition is usually caused by excess hydrogen in the gas, and will occur when the quantity of hydrogen reaches about 4.6 per cent., depending also upon the cleanliness of the cylinders. This premature ignition is an indication of leaky cooling plates in the furnace.

MISCELLANEOUS

The pistons of the early large gas engines were of cast iron, but these gave considerable trouble by cracking because they were not properly ribbed. Several builders changed to cast steel, but found they gave trouble either by cutting the cylinder walls or by beading over and binding the rings.

Cast-iron snap rings of uniform cross-section give better service than any other type. Piston rod packing furnishes one of the difficult problems for the designer and also for the operator. A good packing must be simple in design, and, as in the case with the piston rings, the forms with the fewest parts seem to give the best service. Both cast iron and babbitt have given good results.

A daily log of the various pressures and temperatures must be kept to learn whether the plant conditions are changing and to know the cause of these changes. Any unusual occurrence or the regular recurrence of repairs noted on the log sheets puts the information regarding the plant where it can be used in predicting and preparing for the future.

Exhaust-Valve Trouble

The engine at our factory ran very well for a few months, after which trouble began first with the exhaust valve and ending with the gear on the end of the governor spindle being stripped.

The exhaust valve was of cast steel with a solid head and hollow stem. The cooling arrangement for this valve seemed to work fairly well, but the face of the valve continually burned and gave no end of trouble. In the meantime we were experiencing trouble with the governor. We at first thought that the camshaft must be out of alignment, accordingly when closed down on Sunday we set to work about the camshaft. This was jacked up enough to take out the center bottom brass; the old babbitt was removed and the bearing rebabbitted, allowing a heavier setting than before, also a new gear of special temper was fitted onto the governor spindle.

When started again the engine ran very well without load for about an hour, but as soon as the load was put on, it refused to carry any more than half its capacity and the center bearing showed a tendency to run hot.

While we were having our troubles with the engine, a new exhaust valve had been designed by the head machinist. This valve was made in two pieces, the head being of cast iron and the stem of steel. The head was hollow to allow sufficient space for a water jacket, the cooling water passing up one side of the stem through the valve jacket and down the other side of the stem. This type of valve has been giving satisfaction for a long time now, but we have to keep two or three on stock, so far. The stem is riveted over inside the valve head, and is apt to become loose. One valve will run a month, night and day, without grinding.

I am of the opinion that the whole trouble was in the exhaust system, the steel valve not seating right allowed burnt gases to be drawn into the combustion chamber, leaving carbon deposits on the valve and seat, at the same time throwing a strain on the camshaft, which was transmitted through to the governor spindle and caused a binding action between the shaft gears and governor gear.

This engine is running 24 hr. a day on natural gas and is giving entire satisfaction. A cast-iron valve was made recently and experimented with. This valve was cast in one piece with a water jacket in the head. A ¼-in. gas pipe was placed in the stem for cooling purposes. The water passed up the pipe and returned down inside the stem. The valve worked all right for one week, but, unfortunately, the stem broke about 2½ in. from the end.

Wallaceburg, Ont., Can. W. M. GREY.

REFRIGERATION DEPARTMENT

The Absorption System

In this department an explanation of the working of this system has been given. The description was elementary and the illustration included only the principal apparatus such as the absorber, generator and condenser. To get the best economy out of the system numerous auxiliary apparatus are required and in the present article the intention is to illustrate the full equipment of a commercial plant. Briefly, the apparatus consists of an absorber, ammonia pump, exchanger, generator, analyzer, weak liquor cooler, dehydrator or rectifier, condenser, ammonia receiver, regulating (expansion) valve, and the brine cooler. These various parts of the system may be furnished in the shell and coil, shell and tube, atmospheric or double-pipe counter-current types. Depending on the composition of the cooling water, space available and other factors, a choice is made of these types, but whatever the construction, the different designs serve the same purpose.

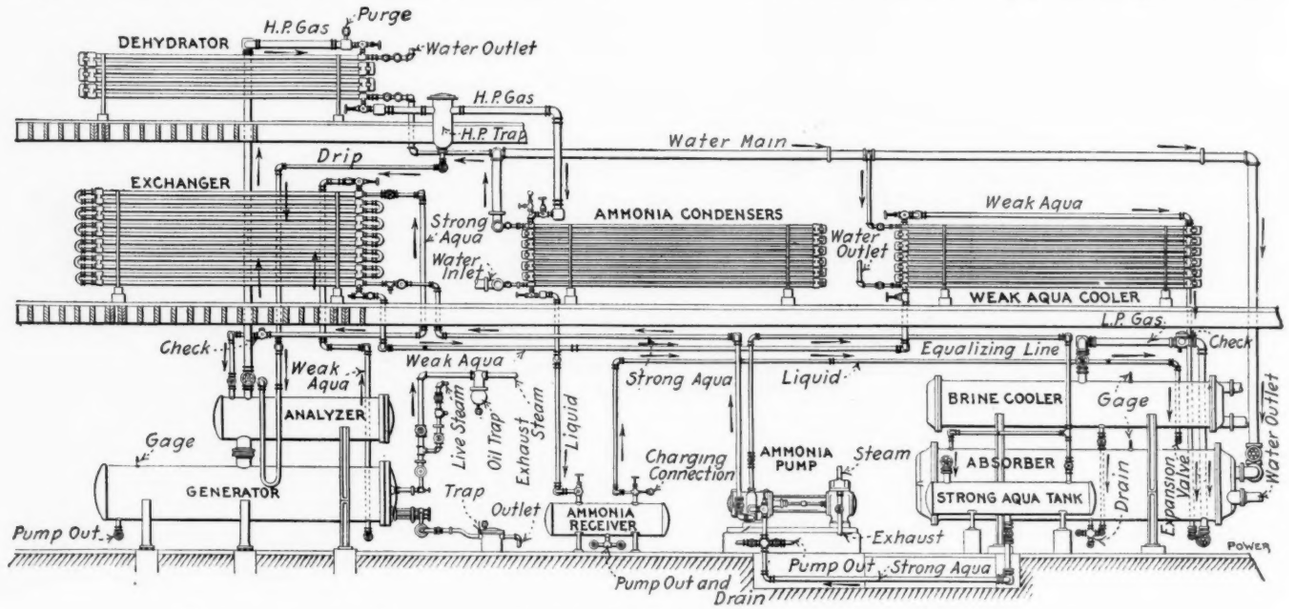


FIG. 1. TYPICAL LAYOUT OF ABSORPTION SYSTEM WITH DOUBLE-PIPE AUXILIARIES

For illustration a commercial system using double-pipe counter-current auxiliaries will be taken, although the shell-and-coil apparatus of the vertical type occupy less room and have been more generally used in small plants.

In describing the accompanying illustration, we will start with the ammonia receiver which collects the cold liquid ammonia from the condenser. This tank is under the same pressure as the condenser and when the valve at the tank and the regulating valve at the brine cooler are opened, the liquid ammonia is forced into the coils of the brine tank. Here it absorbs heat from the brine and, as explained in the previous article, changes into a vapor which passes on to the absorber. The weak liquor (most of which is water) in this apparatus has a great affinity for ammonia vapor and will absorb from 500 to 1000 times its own volume depending on its temperature and the amount of ammonia already in the liquor. When enough ammonia has been absorbed to make about 28 per cent. of the total weight, the liquid, then known as strong liquor, is pumped through the exchanger and analyzer to the generator. Here heat is applied by means of steam coils and the ammonia being more volatile than the water is evaporated and passed on to the condenser. The water, or rather weak liquor, as there is still some ammonia left in it, is returned through the exchanger and a weak liquor cooler to the absorber.

In the illustration a double-pipe exchanger is shown. The cold strong liquor on its way to the generator passes through it in one direction and the hot weak liquor goes back to the absorber in the opposite direction. An exchange of heat takes place which adds to the efficiency of the plant. In the generator the strong liquor must be heated, and part of this heat might better be supplied by the weak liquor which must be cold before it gets back to the absorber. The exchanger does not remove all of the heat so it is necessary to use the weak liquor cooler to lower the temperature of the liquor. As will be apparent, the same water used in the condenser is passed on to the cooler, and then to the absorber itself, where the weak liquor is finally reduced to the proper temperature. The weak liquor enters the bottom of the absorber and when saturated with vapor passes into the strong liquor tank, which is used in this particular case. More frequently the strong liquor settles to the bottom of the absorber.

From the exchanger the cool strong liquor passes to the analyzer where it trickles over a series of metal trays or some construction which will distribute the liquid and allow it to come in close contact with the hot vapor rising from the generator. The counter-current principle of cooling is thus again employed, so that with an analyzer of large capacity the strong liquor should be very near the boiling point by the time it reaches the generator. On the other hand the vapor is cooled and the condenser is relieved of part of its work.

Where ammonia liquor is boiled not only ammonia vapor, but also a small percentage of water vapor is formed. This mixture, if condensed, would form a strong ammonia liquor, which would cause disturbances in the cooling coils by the formation of ice. When the vapor mixture meets the cooler strong liquor in

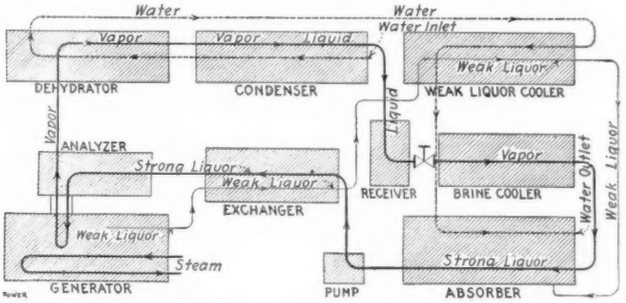


FIG. 2. TRACING THE AMMONIA, WEAK LIQUOR AND WATER

the analyzer some of the water vapor will be thrown down and returned to the generator. The balance is condensed in the dehydrator, or rectifier as it is more commonly called, the vapor practically free from water vapor passing on to the condenser and the moisture back to the analyzer. It may be noticed that the rectifier is nothing more than a double-pipe cooler employing the counter-current principle. In the condenser the vapor is reduced to a liquid by the use of plenty of cooling water and returned to the ammonia receiver. This completes the cycle of operation, which is constantly repeated with a fresh supply of ammonia from the receiver.

To trace the path of the ammonia in the form of liquid and vapor and also the strong liquor, Fig. 2 will help. The paths of the weak liquor and the cooling water are also shown. The apparatus of the system have been blocked in and for simplicity given a little different arrangement. The arrows on the lines indicate the directions of flow. The heavy line indicates the path of the ammonia from the receiver back to the receiver, the light line the path of the weak liquor and the dotted line traces the cooling water. The diagram is self-explanatory and may perhaps fix in mind a little more clearly the relations to each other of the various parts of the system.

Ice and Salt Mixtures

BY GILBERT H. CRAWFORD, JR.

In certain sections of the country where ice is cheap considerable commercial refrigeration is accomplished by the use of freezing mixtures of crushed ice and salt. While this branch of the refrigerating industry is comparatively small it is of enough importance to warrant an occasional discussion.

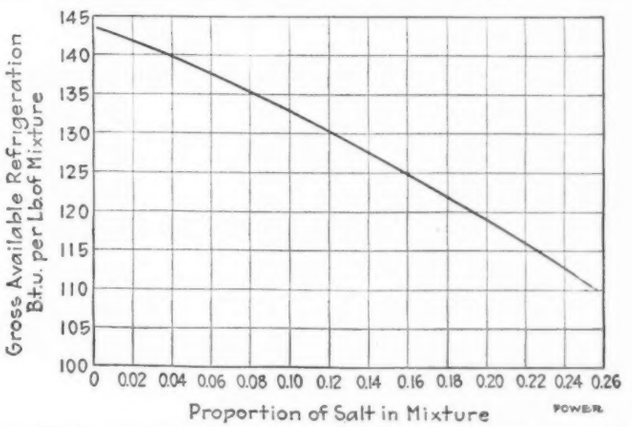
The action of common salt (sodium chloride) and ice is to lower the mixture temperature below 32 deg. The depression of temperature depends mainly on the proportion of salt used, and partly on the rate at which heat is supplied from the outside. The following table gives the approximate temperatures resulting from the use of different proportions of salt and ice.

Per Cent. of Salt in Mixture	Temp. of Mixture, Deg. F.
5	26.6
10	19.9
15	11.8
20	1.6

The minimum temperature obtainable with ice and salt is about —7.5 deg. F., this temperature being given by a 24 per cent. mixture.

In melting, the ice absorbs its latent heat of fusion at the rate of 144 B.t.u. per lb. of ice melted. The salt on dissolving also absorbs heat—called the "heat of solution," which varies in amount, depending on the density and temperature of the resulting brine.

As steam quantities are calculated from and at 212 deg. F., so it is convenient to calculate the available refrigeration due to the melting of an ice and salt mixture from and at 32 deg. F. The accompanying curve shows the relation between the proportion of salt in an ice and salt mixture and the available refrigeration per



REFRIGERATION AVAILABLE WITH VARYING PERCENTAGES OF SALT

pound from and at 32 deg. F. Corrections to the available refrigeration must be made if the salt is added to the ice or if the resulting brine be allowed to escape at temperatures other than 32 deg. F.

These corrections are easily calculated by multiplying the weights of salt and brine by their respective specific heats and by their temperature differences from 32 deg. F. The specific heat of dry salt may be taken at 0.214 B.t.u. per pound-degree. The specific heat of salt brine varies with its density and may be taken from the following table:

Per Cent. Salt	Specific Heat of Brine
0	1.000
5	0.945
10	0.916
15	0.874
20	0.832

If the salt is warmer than 32 deg. F. when added to the ice—the usual case—the correction for its heat above 32 deg. F. must be subtracted from the available refrigeration. Likewise the correction is negative for the refrigeration thrown away if the brine is discharged to

waste at a temperature lower than 32 deg. F. If the brine is allowed to absorb heat until its temperature is raised above 32 deg. F. before discharge, its correction is added to the available refrigeration.

This may all be expressed algebraically as follows:

$$H' = H - 0.214\,p\,(t_s - 32) - C_b\,(32 - t_b)$$

where

H' = Net available refrigeration per pound of mixture;
H = Gross available refrigeration per pound of mixture from accompanying curve;
p = Proportion of salt expressed as a decimal;
t_s = Temperature of salt when added;
t_b = Temperature of brine to waste;
C_b = Specific heat of brine corresponding to proportion p.

EXAMPLE—What net available refrigeration is there in a mixture of 100 lb. of dry salt with 900 lb. of ice, when salt is 60 deg. F. when added to the ice and the resulting brine is allowed to discharge at 25 deg. F.?

$$p = \frac{100}{100 + 900} = 0.10$$

From the curve for $p = 0.10$, $H = 132.8$ B.t.u. The specific heat of 10 per cent. brine is 0.916 B.t.u. per pound-degree. Then

$$H' = 132.8 - [0.214 \times 0.10\,(60 - 32)] - 0.916\,(32 - 25) = 125.8\ B.t.u.$$

per pound of mixture.

❋

Condenser and Back Pressures

The proper pressures for the condenser and the low-pressure side of the system is a question which every engineer has to solve for his own particular plant. In each plant the conditions will be a little different and the pressures which will give the highest economy will depend on the temperature of the cooling water, the amount of water supplied, the square feet of cooling surface in the condenser per ton of plant capacity, the temperature it is desired to maintain in the refrigerator and the amount of noncondensible gases present.

If the surface in the condenser is known to be correct and there is little trouble from noncondensible gases, then the following data given by F. E. Matthews may be taken as an approximate guide. Table 1 gives the proper condenser pressures for different temperatures and quantities of the cooling water and Table 2 the back pressures used in average practice to maintain certain temperatures in the refrigerator.

TABLE 1. CONDENSER PRESSURE

1 Gal. per Min. per Ton per 24 Hr.							
Temp. of cooling water, deg. F.	60	65	70	75	80	85	90
Condenser pressure, lb. gage	183	200	220	235	255	280	300
Temp. of condensed liquid ammonia, deg. F.	95	100	105	110	115	120	125
2 Gal. per Min. per Ton per 24 Hr.							
Condenser pressure, lb. gage	130	153	168	183	200	220	235
Temp. of condensed liquid ammonia, deg. F.	77	85	90	93	100	105	110
3 Gal. per Min. per Ton per 24 Hr.							
Condenser pressure, lb. gage	125	140	155	170	185	200	215
Temp. of condensed liquid ammonia, deg. F.	75	85	90	93	95	100	105

TABLE 2. BACK PRESSURES

Temp. of room, deg. F.	5	10	15	20	28	32	36	40	50	60
Back pressure, lb. gage	7	10	12	15	22	25	27	30	35	40
Temp. of ammonia, deg. F.	−13	−10	−5	0	8	12	14	17	22	26

The pressures given in the tables will be close to the mark, but in some cases it may be possible to obtain a slightly higher efficiency by the cut-and-try method, that is, adjusting the pressures on both sides of the system until the maximum result is obtained. In any case the condenser pressure should be as low as possible and the back or suction pressure as high as possible and still maintain the desired temperature in the refrigerator. The range in pressure should then be made as small as possible, the action being just the reverse of a steam system where results are bettered as the range of pressure increases.

When the proper pressures have been determined it is important that they should be maintained. The easiest and probably the best way to do this is to install thermometers in the suction and discharge pipes of the compressor. Each temperature corresponds to a certain pressure and by marking or indicating in some way the proper height of the mercury column, it is an easy matter to see at a glance when the temperatures are above or below normal.

In the spring and fall when the temperatures of the air and cooling water are lower, it is possible to reduce the range in pressure from that used in the hot, summer months. To obtain the highest economy, adjustment of pressures should then be made at least three times during the season. It is a simple matter and only requires ordinary intelligence on the part of the operating engineer. A short time ago a case was cited in these columns, where the output of an ice plant was increased over 50 per cent. by raising the temperature of the compressor discharge from 104 to 240 deg. F. The latter proved to be the proper temperature for the existing conditions, and the case goes to show that it is well worth while to pay some attention to the operating pressures.

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Rating Refrigerating Machines

In this country there are two generally accepted units for rating a refrigerating machine. These are commonly called the ice-melting or refrigerating capacity, and the ice-making capacity. Both are expressed in tons of 2000 lb. per day of 24 hr. When a machine is rated at one ton ice-melting or refrigerating capacity, it would mean that under an assumed range of operating temperature it would remove from the refrigerator the number of heat units equivalent to that required to melt one ton of ice at 32 deg. F. into water at 32 deg. F. The latent heat of ice has been variously taken as 142, 143, 143.7 and 144 B.t.u., but 144 B.t.u. is now the figure generally accepted. Then

$$2000 \times 144 = 288{,}000\ B.t.u.$$

is the equivalent of a ton of refrigeration per day of 24 hr. This would give 12,000 B.t.u. per ton per hour and 200 B.t.u. per ton per minute, all convenient figures to work with. The machine is supposed to work between a condenser temperature of 90 deg. F., and a temperature of zero in the expansion coils.

The ice-making capacity is a measure of the actual weight of ice made by a machine, designed for the purpose, in tons per 24 hr. For a machine not designed for ice making this unit would appear of little value, but for the sake of comparison it is approximately six-tenths the ice-melting or refrigerating capacity.

EDITORIALS

Analysis and Heat Value of Coal

With the growing unit cost of coal, continually sharpening competition and spreading enlightenment as to the principles of efficient combustion and boiler operation, increasing demand came for adequate simple means of predicting results to be expected with a given coal under a given set of conditions.

The character and heat value of a coal are two indispensable factors.

The ultimate analysis yields much information as to character, although not all that is often desired, and from it the heat value can be estimated quite closely. Unfortunately, however, the ultimate analysis is a long and complicated process, only to be attempted by a trained analyst, and the special apparatus required is expensive. Consequently, it is seldom performed in commercial work.

The proximate analysis yields less information as to character, still it is of considerable help. It gives the ash and moisture content, a knowledge of which is useful in comparing one coal with another and in selecting a coal to give the most heat for the money spent. It gives the volatile content which is useful in identification and classification. Its strong recommendation, however, is its simplicity and the ease with which it can be made. The required equipment is small and simple; twenty-five dollars will cover the cost of the apparatus with which to obtain sufficient accuracy for all ordinary purposes. The wonder is that the proximate analysis is not employed more extensively. Certainly, the information yielded, limited though it may be, is more than worth the cost of equipment and time required.

The principal drawback is that it is neither a close nor consistent guide to the heat value. This is because it does not show the oxygen content of the coal, which has an important influence on the heat value. In the Bureau of Mines Bulletin 29 on "The Effect of Oxygen in Coal" this influence is shown to be of about equal importance with that of the ash content. Thus, all methods of estimating heat value by calculation which do not take the oxygen as well as the ash into account are subject to large error even with coals from the same general district.

This fact was brought out by charting some three hundred analyses according to the heat value of the combustible and the percentage of fixed carbon in the combustible. With this system two of the three variables influencing the heat value are eliminated, ash and moisture. The third, oxygen, remains to cause a variation as high as six per cent. in the heat value of the combustible matter of coal from the same general district and containing practically the same percentage of fixed carbon.

Attempts have been made to calculate the oxygen content from the proximate analysis, at least, by elimination, but, as no good law has yet been discovered, heat-value estimates based on such attempts are subject to the same or even greater degree of error as the older and simpler methods. In time, some good law may be discovered, but it is doubtful whether it will be found to be simple enough for extensive application.

Aside from the ultimate analysis, the calorimeter is the only means at present available of estimating the heat value with reasonable accuracy and consistency. In its existing form it is more or less expensive and complicated. Before it can be popularized it must be perfected in simplicity and sold at such a price as to bring it within the means of the individual to buy. And the number of its possible users is so great that this seems well worth the effort.

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The Value of Cost Keeping

The engineer in the small plant is well aware that the larger the company he may eventually work for, the closer will attention be paid to the detail, and, especially along the line of costs. The statement is made that the larger industries, with their various departments and large number of employees, can well afford to keep careful records, but the engineer in the small plant, who also frequently fills the position of fireman and general repairman, has little or no time to spend on cost records.

But consider how small a job it is to jot down a few items each day. A man who forms this habit will find his work takes on additional interest. He is anxious to read his technical paper carefully so he may grasp any ideas that will improve his plant efficiency and reduce his operating cost.

Perhaps first attention will be given to the coal pile. Although but few plants are equipped with convenient means of weighing coal, a little effort with platform scales and measurement of the coal bin will afford a method of arriving at a close approximation of daily consumption.

Next will come a desire to know the method of firing which will produce the best results. The percentage of carbon dioxide, quantity of air required for combustion, amount of unburned carbon in the flue gases, heats of combustion of carbon dioxide and carbon monoxide, etc., will appear to have a direct bearing on the plant operation. The engineer begins to investigate the chemical side of this coal that he is burning He learns about moisture, ash, fixed carbon, percentage of sulphur, and becomes interested in the various grades of coal Perhaps he can show the purchasing agent that sometimes a good way to buy coal is by the B.t.u. shown on test.

He will look over his boilers more carefully the next time the inspection is made. The water required for the boiler will bring to mind that his technical magazine a few copies back had something about factor of evaporation, temporary and permanent hardness of water, and also told about the loss of boiler efficiency caused by even one-sixteenth of an inch of scale.

The engineer who has started keeping a record of his operation cost will want to sell his cinders to some contractor, the revenue so obtained will appear to advantage on the credit side of his cost sheet. At the same time,

attention will be directed to the furnace grates, stokers and all firing equipment, so that dollars in heat units are not being traded for cents to the cinder-man.

Perhaps a saving can be made by having the feed water enter the boiler at a higher temperature. While working out this problem the terms latent heat of steam, heat of the liquid, heat of vaporization, etc., will become like old friends.

Next, attention will be given to the engine. Perhaps it has been some time since any cards were taken, and it will be found that one side is doing a lot more work than the other. A little valve adjustment will materially help the division. At the same time the presence of a strange hook or loop will cause the engineer to refresh his memory on the features of the indicator diagram.

The matter of lubrication will assume even greater importance when appearing on the cost records. The terms viscosity and specific gravity will be found to have some relation to the periods between each order for oils.

The various pumps in the plant may be taking more steam than they should, and perhaps a closer investigation of the subject of packing may aid in stopping both steam and water leaks, and also lead to a reduction in the packing bill for the year.

Only a few items have been mentioned which would appear on the record of operation costs. There are items which would be peculiar to every plant. What has been gained by the time taken? The engineer knows more about his plant than he ever did before.

It is only natural that the engineer who has become familiar with the actual operating costs of his plant will be anxious to inquire about what are termed overhead charges, especially those that pertain to his department. He knows that the items interest, taxes and insurance enter into power-plant cost, as well as depreciation. Perhaps he has felt that depreciation is the only one he should think about, but the engineer will do well to inform himself regarding interest, taxes and insurance, since they do have an important bearing on the present plant and will be the first to be considered when the growth of business demands either an enlargement of the power plant on the present site, or a moving to a location better suited both from a geographical and economical viewpoint.

The item depreciation may be considered as embracing physical depreciation and functional depreciation. Physical depreciation, or wear and tear, appeals directly to the engineer, since it represents the results of his care and attention to all parts of the equipment in his department. Functional depreciation, he may feel, does not apply so directly to him. However, as this represents the advance in design or the modification of machines which places on the market a machine that will perform work more economically than some which may be in his plant, it often pays to make the change, even though the old machine is still in fair or even good condition. The engineer, with his superior knowledge of the advancement of the science of engineering, can frequently point out financial leaks that would escape the man in the office.

The engineer of the small plant sometimes dreads the coming of central-station service, since he fears it will deprive him of his position. Often his fears are groundless, for when he starts keeping his own costs, and actually figures what he is accomplishing, he knows in cents or fractions of a cent per kilowatt-hour or horsepower-hour by how much he can beat the central station. A well kept cost record is a good thing to lay beside the central-station results of plant test.

As previously mentioned, only a few items have been suggested as appearing on a record of costs; every engineer can name others. But the main point is this, the engineer who has kept his costs of operation for the year systematically can show his employer results and he knows that his own engineering knowledge has become broader. Surely a habit containing such a twofold blessing is worth a little time and effort.

Boiler-Efficiency Chart

On another page of this issue is to be found a "Boiler-Efficiency Chart" devised by John C. Parker of the Parker Boiler Co. Our readers may recall a chart of a similar nature, though in somewhat different form, by F. O. Pahmeyer, that appeared in the issue of July 23, 1912. Mr. Parker had previously exhibited at a meeting of the A. S. M. E. the chart printed herewith, which was copyrighted at an earlier date than Mr. Pahmeyer's, although the charts were plotted independently.

Both attain practically the same results and are plotted to coördinate axes. The reader is left to choose that which meets his particular needs.

Selection and Use of Cylinder Lubricants

In these days of close attention to power-plant performances, when many plants are running continuously under test conditions to determine what kind or mixture of coal will evaporate the most water, it is true that too little attention is paid to the selection of steam-engine cylinder lubricant as Mr. Lawrence intimates in his article, in this issue.

Bring up the subject of lubricant selection and the efficiencies of lubricants, especially cylinder oils, among most engineers and the discussion dies at the moment of its birth because so little accurate data are available that few can intelligently discuss the question. Yet it is very important to know if the best lubricant has been selected, price considered, and whether or not the proper quantity is being supplied to the units after the best has been purchased.

Feeding enough oil or lubricant to an engine or pump cylinder to keep the unit from grunting, regardless of all other conditions, cost included, is altogether too common.

It is hoped that the article referred to may induce many engineers to discover what lubricant is best suited for their equipment by determining the number of horsepower-hours per gallon per unit of cost that the lubricant will give under normal conditions of saturated or superheated steam.

When a minimum consumption compatible with good running is discovered for each engine, it should not be difficult to establish and approximately maintain a standard.

It is inconsistent to bewail the loss of a few pounds of coal at, say, three dollars per ton, while ignoring the loss of half a pint of oil at thirty-five cents per gallon.

QUESTIONS BEFORE THE HOUSE

"Keyed" Check Nut

In order to guard against the defect of unlocked nuts on machinery, a millwright having charge of a large mill drilled a hole from the end of the nut, half in the nut and half in the bolt, and filed a "V" in a piece of soft wire which was driven into the hole.

After the introduction of this practice, no trouble was experienced with loose or lost nuts and the possibility of damage to life and machinery was reduced to a minimum.

CHARLES F. SCRIBNER.

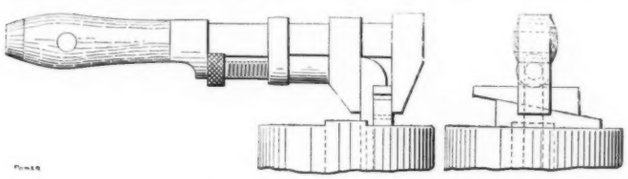
Hartford, Conn.

[This manner of making a nut fast is not new, but mention of it here may serve as a reminder for those who have forgotten it.—EDITOR.]

Removing Solidly Driven Keys

Those who have trouble in removing head-keys from the valve-gears of Corliss engines and other places will find that all trouble may be avoided by adopting the following method of removing the keys.

Place a monkey-wrench over the key as shown, and insert a compound wedge between the jaws of the wrench



SHOWING USE OF WRENCH AND WEDGES FOR REMOVING KEYS

and under the head of the key. By applying a pressure on the end of the wrench and at the same time driving the wedges or cold chisels, whichever is used, the key will slowly and surely come out.

JOHN F. HURST.

Louisville, Ky.

Engine-Driven Fan Increased Combustion

Possibly some reader may be interested in one detail of a steam plant I have been remodeling.

There are two boilers; one 6x18 ft. with 110 three and a half-inch tubes, the other 6 ft. 6 in. by 18 ft. with 118 three and a half-inch tubes. One boiler had a 36-in. smoke flue leading to a chimney 60 ft. high, with a 36-in. square flue. The other boiler had a 36-in. flue leading to a 36-in. steel stack 60 ft. high.

As there were times when the draft was insufficient, I designed an induced-draft arrangement, which works very satisfactorily. As the space was limited the fan and direct-connected engine were placed on a steel-beam platform above and in front of the boilers. The boilers were connected to a U-shaped breeching and the fan inlet was attached at the center of the U. The exhaust flue was connected with the chimney.

The fan engine was fitted with a variable-speed governor, allowing for a 50 per cent. variation in speed. A chronometer valve was placed on the steam pipe to the engine, and the lever of this valve was connected with the damper regulator. In this way the speed of the fan was regulated by the pressure which seldom varies over 2 per cent.

These boilers are in continuous service day and night, and in a test of 25½ hours' duration made recently, evaporated 10.9 lb. of water from and at 212 deg. per lb. of bituminous coal.

Fourteen samples of flue gas were analyzed, showing an average of 11.45 per cent. CO_2. The temperature of the flue gases varied from 370 to 500 deg. The draft gage varied from 1 to $\frac{3}{10}$ in.

S. E. DART.

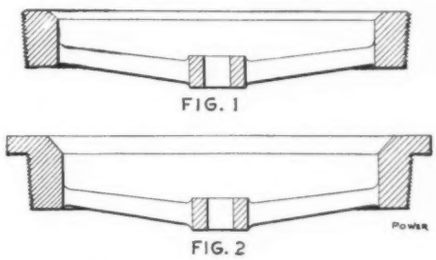
Troy, N. Y.

Leaking Throttle Valve Repaired

The throttle valve on a 1000-hp. cross-compound engine leaked badly, and I was asked to investigate and make repairs. The practice had been, so the attendant stated, to use the starting bar for a lever in an endeavor to tightly close the valve.

Conditions left no reason to doubt that this practice had been indulged in by the attendant.

Fig. 1 shows the seat casting which was without a flange or shoulder, and was probably originally threaded to the pipe, standard taper, viz., ¾-in. to the foot, ap-



VALVE-SEAT CASTINGS

proximately 8½ in. diameter, and 16 threads per inch. This fine-pitch thread was stripped entirely, allowing the valve seat to be pushed by the disk into the hole in the valve casting, until the guide stem brought up against the back of the valve body, the guide stem being badly bent, showing that a lever had been used to close the valve.

The valve stem proper is 1½ in. in diameter, with a four-pitch square thread, and fitted with an 18-in. diameter wheel. Clearly, then, this made an excellent "jack," using a 42-in. starting bar for a lever, to strip the 16 pitch threads on the seat casting.

Repairs were made by straightening the guide stem

and making a pattern for a new seat, as shown in Fig. 2, with a flange or shoulder ¾ in. larger in diameter than the threaded part and about ⅜ in. thick. This was then threaded to fit the valve casting, so that when screwed down all the way, the shoulder would be set firmly against the iron. Since doing this there has been no trouble in closing the valve tightly by hand.

Columns have been printed on the subject of opening throttle valves wide. More columns should be printed, and read, in an attempt to discourage the practice of using bars and levers on throttle valves, or in fact any kind of valve. When a valve cannot be shut tightly without resorting to this kind of abuse, it is time it was repaired.

H. R. Low.

Moosup, Conn.

Coal Wasted through Ashpit Doors

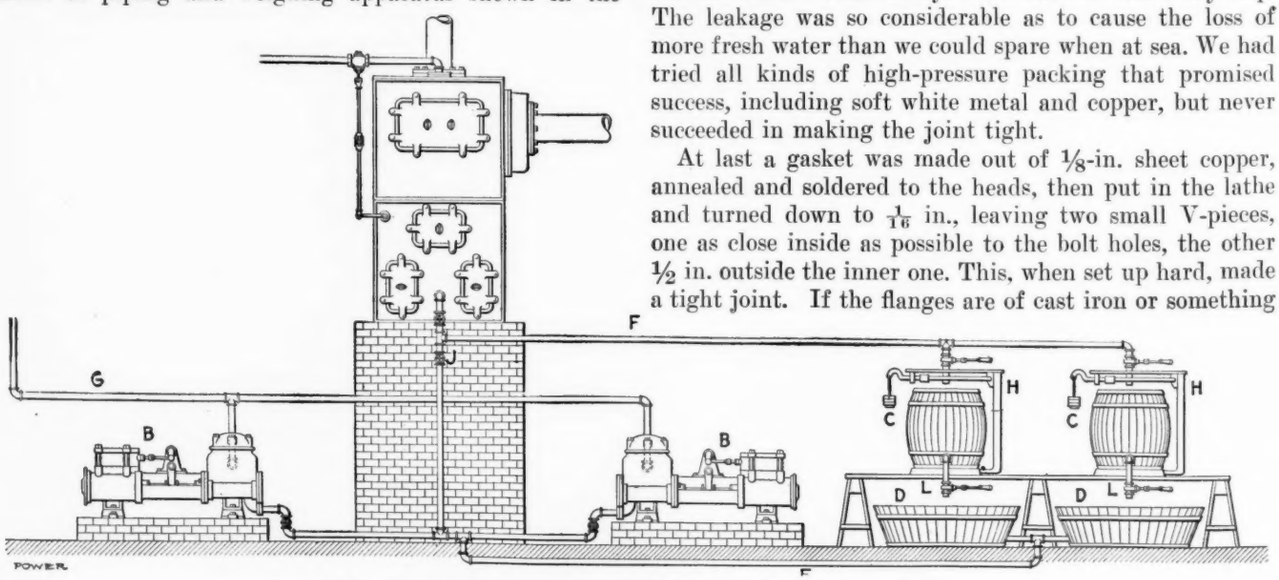
Recently, in taking charge of 8000 hp. of boilers I found that considerable coal was wasted by falling off of the shovel in firing and going into the ashpit through the ashpit doors. We have 14 boilers, having a total of 60 firedoors and ashpit openings. I found that about 90 shovelfuls of coal were lost each day. To overcome this loss I had screens made of ¼-in. mesh heavy galvanized-iron wire and 1-in. wide by ¼-in. thick iron serving as the material for the frames. We burn No. 2 buckwheat coal and these screens placed in front of the ashpit doors prevent coal from entering the pits and being wasted.

J. T. Fennell.

Philadelphia, Penn.

Measuring Water in Boiler Test

Where neither a feed-water meter nor a weighing tank has been provided on the boiler-feed lines, the arrangement of piping and weighing apparatus shown in the accompanying illustration may be used to ascertain the weight of the water being pumped to the boilers. The weighing barrels and scales, shown in the sketch, can be easily connected up to the piping in any boiler room. The arrangement shown here is in connection with an open feed-water heater and two cross-connected feed pumps.



Arrangement for Weighing Water in Boiler Test

From the feed-water heater discharge to the feed pumps *B* a connection *F* is carried over to the weighing barrels *C*. The inlets from pipe *F* to the barrels are each provided with a valve, preferably a quick-closing valve to permit of the barrels being rapidly refilled.

Barrels *C* are placed on the weighing scales *H*. When valve *J* is shut, the feed water from the heater is diverted to the barrels, and when these are full, the gross weight of each barrel and its water contents is recorded. The valves *L* are then opened and the water emptied into the tubs *D*.

A common suction for the two pumps is connected to the tubs, and the water is pumped from the tubs to the boilers through pipe *G*. When the barrels have emptied, the weight of the empty barrel, with a small amount of water which always remains in the bottom, is obtained, and the difference between this weight and the gross weight of the full barrel represents the weight of the feed water pumped to the boilers.

When a boiler test is being conducted with this weighing apparatus, each barrel is weighed and filled alternately. If the filling and emptying connections to the barrels and tubs are of ample area, say 2 or 2½ in. in diameter, the outfit shown in the sketch will handle an hourly load up to 1000 boiler horsepower.

New York City. James A. McHollan.

Copper Ring V-Gasket Stops Leak

The plant of our ship had a capacity of 16,000 hp. We were supplied with two feed-water heaters, 28 in. in diameter, with thirty-two 1⅛-in. studs to keep the heads tight. The back pressure of 8 lb. on the auxiliary exhaust was trapped into a feed tank. The heaters worked nicely, supplying feed water at from 210 to 220 deg. F., but the heads would always leak more or less every trip. The leakage was so considerable as to cause the loss of more fresh water than we could spare when at sea. We had tried all kinds of high-pressure packing that promised success, including soft white metal and copper, but never succeeded in making the joint tight.

At last a gasket was made out of ⅛-in. sheet copper, annealed and soldered to the heads, then put in the lathe and turned down to $\frac{1}{16}$ in., leaving two small V-pieces, one as close inside as possible to the bolt holes, the other ½ in. outside the inner one. This, when set up hard, made a tight joint. If the flanges are of cast iron or something that solder will not adhere to, any other method that will hold the gasket in place will do, as the solder is only used to hold the copper while working it.

G. D. Kramp.

Philadelphia, Penn.

QUESTIONS BEFORE THE HOUSE

Problem in Power-Plant Economics

In regard to L. W. Chadwick's question, in a recent issue, as to power-plant economy, my personal opinion is that it would be far more economical to purchase a new engine than to overload the old one over 50 per cent. If the overload was temporary, say, for a period of four or five years, it might not be economical to purchase a new engine, but as the additional load is permanent and considering the waste of steam with a late cutoff and the increased rate of depreciation, not to mention the danger of a possible accident, due to hazardous engine speed, it would, undoubtedly, be more economical to purchase a new engine.

However, this is a question that can best be answered by the use of operating-cost accounts. If these show a saving by operating at a more efficient load sufficient to cover a fair rate of interest on the cost of a new engine, then buying a new engine would be a good investment. Then, too, it might be cheaper to compound the old engines or to install a condenser. All this depends on conditions in this particular plant, and cannot be decided without a thorough study of the situation. The problem is one that a competent consulting engineer should be employed to investigate and solve.

E. F. Goad.

Decatur, Ill.

Charging for Electric Current

Evidently from writings that have appeared in Power, its readers greatly misunderstand systems of charging for electric current. From the synopsis to W. H. Booth's article in the Apr. 1 issue the editor is in the same position. Indeed, very few not connected with the electric-light business give the matter enough attention to get a clear conception of the problems involved. The principles governing the making of rates for electric service and for the sale of merchandise are radically different; electric current cannot logically be sold like groceries.

Why some features of a system for charging for electric current appear ridiculous when applied to the conduct of a country store is because they do not apply. Central-station men are, no doubt, actuated often by the desire to get business when they adopt a system of charging, but most so called ridiculous systems result from an honest effort to make each customer pay in proportion to what it costs to serve him.

In Mr. Booth's country store each bloater cost the merchant the same, but it is less work to sell a crate to one customer at once than a bloater at a time; therefore, if the merchant charges each customer what it actually costs to serve him, he will charge less per bloater by the crate than one at a time, or, he will sell at the same price each for the bloaters but will charge less for waiting on the customer, when he has only one to wait on instead of many. It takes no longer to pass out a crate than to wrap up a single bloater.

The writer once had to deal with a restaurant keeper, who was offered by the light company the option of two systems of charging, one a sliding scale based on quantity used and the other the so called "readiness-to-serve" schedule. The place was small and kept open late. Therefore it used a great many kilowatt-hours in proportion to the number of lamps. Under the sliding scale the man paid quite a large light bill, but he would not listen to the advantages of the "readiness-to-serve" schedule. As it made his light cost him several dollars a month less, the writer voluntarily billed him by that schedule, but he would roar every month about that "readiness-to-serve" charge, which he did not understand and still he would not listen to explanations. Finally he was sent two bills, one made out on the sliding scale and the other on the hated "readiness-to-serve" schedule, with a letter telling him to pay whichever one he chose. It took no mental effort for him to see that one bill was three dollars less than the other.

In addition to paying for fuel and labor a lighting plant must pay taxes, insurance, depreciation and maintenance before paying interest on the investment. If one were asked to install a plant to supply 720 kw.-hr. per month and to fix the price per kilowatt-hour, how would he proceed? With the data given he would be stumped. He would not know what size plant to install and, therefore, could not estimate what charge to make for labor, fuel, taxes, insurance, depreciation or maintenance. He might be required to be ready to deliver the whole 720 kw.-hr. without a moment's notice at any instant during the month or to deliver only one kilowatt per hour continuously. Obviously the price per kilowatt-hour must depend on the factor of "readiness-to-serve" which is simply a short way of saying, taxes, insurance, depreciation, maintenance, interest on investment, etc.

Take a concrete case. A plant was desired for a small town which has no prospect for growth. To be economical the plant must be just large enough and an estimate made of the probable demand of each customer. It was concluded that 25 kw. would be large enough and that 100 customers would be secured. Some of these would use several lights for a short time each evening and some only a few but for longer periods. The franchise required that the company be prepared to furnish service to all who might apply for it. The completed plant cost about $8000. In effect, a part of this investment was made for each of the 100 customers and this portion is nearly directly proportional to the most current the customer would demand when the load on the plant is at the peak. Some of the investment is made when the customer is connected, but most of it when the plant is installed. But to all intents and purposes the money is tied up for that particular customer's benefit and the company is compelled by law to tie up most of this money because the company must serve all who apply or forfeit its right to do business.

Mr. Booth's merchant is under no obligation to supply all the bloaters that might chance to be called for. More-

over, if his stock of bloaters becomes exhausted, he can replenish it quickly. When more service is demanded than a central station can furnish, its capacity is not easily increased.

In the case under consideration the rate per kilowatt-hour was fixed at 15c., because it was thought that would be all the traffic would bear, but to yield a reasonable income on the investment the rate would probably have been higher. A minimum charge of $1.50 per month was made. Suppose a customer uses 10 kw.-hr. a month; he would just use his minimum, and suppose he uses this amount by burning his lamps a short time each evening over the peak, or when the load on the plant is the highest, and suppose the $1.50 is a fair price for the service rendered and paid for this customer's share of the investment. Again, suppose this customer, by burning the same lamps more hours, should use twice as many kilowatt-hours, should he pay twice as much? By no means. He has already paid his share of the investment and now he should only have to pay for what the additional current cost plus a fair profit. At this little plant the additional current can be generated at the cost of 10 lb. of coal per kilowatt-hour or about 0.014c. per kw.-hr. Is it logical to charge the customer 15c. for what only costs about 1½c.? Central stations do not charge the same for every individual kilowatt-hour sold, because each one does not cost the same.

Suppose the customer uses twice the number of kilowatt-hours by burning twice the number of lamps for the same length of time. Then his service will cost the company nearly twice as much and he should pay about twice as much. The plant mentioned does not give day service, but only runs from dusk until dawn. A certain customer has lamps requiring 1½ kw. and averages about 80 kw.-hr. per month, for which he pays the 15c. rate. If this customer used his lamps all night every night he would use about 540 kw.-hr. per month. The additional 460 kw.-hr. would require the burning of only about 2.3 tons more coal and but very little other expense. Therefore, the 460 kw.-hr. would cost the light company less than the first 80. Would there be any reason in charging the same rate?

In the foregoing the writer has not attempted to take into account all the factors involved but only to show why the same system would not apply to electric service and a country store. In devising a system of charging for electric service, the above and other factors must be considered, and the problem becomes very complex. Its complexity accounts for many of the seemingly ridiculous systems in use, and among the difficulties in the way of a simple solution of the problem, one of the greatest is the public's steady refusal to try to understand the matter. It must also be admitted that many persons engaged in the manufacture and sale of electricity have never given the question much study.

G. E. Miles.

La Jara, Colo.

Electric Elevator Questions and Answers

In Mr. Waldron's catechism, published in the issue of May 13, are some answers and explanations which might have been more complete. In his answer to the first question where he speaks of the possibility of the car having run down so far that the counterweights have opened the hatch-limit switch (which is contrary to my experience, the car usually operating the limit switches), he advises working the car up by the use of spanner wrenches.

By holding the potential switch in place, the car may be moved from the board or from the car. This is perfectly safe, and surely much easier than his method. An operator will often allow the car to run down too far with a load, before shutting off the power, thus permiting the car to reach the limit switch and the car is then moved as stated. His answer to the question: "What causes the car to make a solid stop?" is rather puzzling to me. Why should the top shoe be moved rather than the bottom shoe, when the car stops with a jerk on the up motion? Do not the brake shoes set the same for both motions? What would Mr. Waldron do where the brake shoes are set on each side of the brake pulley, and not on the top and bottom?

Relative to his statements about getting a car in service after the safety device has operated, assuring the passengers of perfect safety, and taking up the slack in the hoisting cable is all right, but I do not see how he is going to slacken off the safety clutch before resetting the centrifugal governor on the top of the hatch. He does not specify the particular type of safety he had in mind, but from answers to other questions, judge it is one of those which, when the car is in normal operation, the slack portion of the governor or rather the safety-clutch cable is wound on a small drum, under the floor of the car. When the centrifugal governor, at the top of the hatch, trips (which it can only do when the car is on the down trip), the governor clutch grips the governor cable, pulls it out of the clutch on top of the car and as the car continues its downward course, the cable on the safety drum is pulled off, thus driving the drum around and setting the clutches on the guide rails.

Now, if that clutch will hold a heavy car, and its load, how can a small socket wrench move it until the governor is reset? The governor clutch should be reset before attempting to wind up the drum.

Mr. Waldron might have added to his answer regarding the wear of cables, that the drum-counterweight cables are first to go, owing to the fact that in the single-drum machine located in the basement, the drum-counterweight cables have to make an S-bend over the drum and traveling sheave, where the lifting cables have only a U-bend, thus making the life of the drum-counterweight cables shorter by 30 per cent. than the lifting cables.

Brooklyn, N. Y. W. H. Pyatt.

Comments on Flue-Gas Analysis

Regarding the flue-gas analyses readings submitted by F. A. Lowe, in Power for May 20, it is difficult to comment intelligently on account of the lack of information regarding the coal burned and the apparatus used for sampling and analyzing the gases, etc., but a knowledge of certain general principles may enable him to locate and correct his troubles.

The average totals, that is, the sum of CO_2, CO and O appear high, especially for the percentages of CO_2 obtained, unless the fuel was largely anthracite. With average bituminous coals entering the New England market the amount of hydrogen present in the coal and available

for combination with the oxygen of the air supplied for combustion is sufficient to lower the total of CO_2, CO and O (If CO is not present in too large a quantity, when it causes an appreciable increase in the totals) by about one-sixth of the percentage of CO_2 found, below the value of 20.9, which it would have if the fuel were pure carbon. If a gas analysis shows 15 per cent. CO_2 when burning New River coal, it is to be expected that the sum of CO_2, O and CO (if not over 1 per cent. of CO is present) will be rather close to

$$20.9 - {}^1/_6 \times 15 = 18.4 \textit{ per cent.}$$

The cause of high totals is too large capillary tubes, either in the manifold of an Orsat or in the connections of other forms of apparatus. For example, the volume of the most common form of Orsat burette is 100 c.c. Supposing that that part of the capillary tube from the upper mark on the burette to the stop-cock of the CO_2 pipette contains 1 c.c., then the volume of gas analyzed for CO_2 will be 101 c.c., and if the gas actually contains 15 per cent. CO_2 the decrease in volume will be 15.15 c.c. and will read as 15.15 per cent. CO_2 in the burette. Similarly if the volume of the manifold up to the stop-cock of the oxygen pipette is 2 c.c. and the true percentage of CO_2 and oxygen is 18.4 per cent., the decrease in volume will be 18.77 c.c. and will read on the burette as 18.77 or an increase of nearly 0.4 per cent. over the true total.

If, as some operators recommend, the capillary is filled with water in expelling the last of the old sample and the branches to the pipettes become filled with water, the effect of the large capillary is even more pronounced, as during analysis this water is forced into the pipettes and its place must be taken by gas from the sample, indicating a greater absorption than has actually taken place, equal to the volume of the water contained in the capillary branches. But under whatever conditions the analyses were made I would reject the first analysis in the table presented by Mr. Lowe as the total of CO_2, CO and O equals 22 per cent., whereas if the fuel were pure carbon it could not properly exceed 21.5 per cent. even with this percentage of CO.

Negative readings of CO may be due to three causes: The first and most usual one is a change in temperature of the sample and apparatus during analysis. If the temperature increases the sample expands as the atmospheric pressure at which it is measured remains constant and the result is a lower reading after absorption in the CO pipette than before. Comparatively slight temperature changes will produce this effect. For instance, since the volumes of gases at constant pressure are proportional to their absolute temperatures, to produce the —0.2 CO reading shown in the fifth analysis at 11 o'clock, if the gas sample was at a temperature of 70 deg. F., it would require an increase in temperature of

$$\frac{0.2}{79.4}(70 + 461) = 2.34 \textit{ deg. F.}$$

This can easily occur unless a water-jacketed burette is used and the apparatus is kept out of drafts. The best way to detect this is by a small thermometer suspended in the burette jacket, but if on checking the CO_2 or O absorption, there is a continued apparent increase or decrease of one- or two-tenths per cent., a change in temperature is to be suspected and indications of small quantities of CO_2 should be given little weight.

Occasionally if the cuprous chloride solution is too strongly acid and the apparatus is used in a rather warm place, hydrochloric-acid gas will be given off and increase the volume of the sample, producing a negative CO effect. This is easily detected by passing the gas into the CO_2 pipette where the caustic potash will immediately absorb the hydrochloric-acid gas and give the true reading. This is also useful when ammoniacal cuprous chloride is used, up to the saturation point of the liquid in the CO_2 and O pipettes with ammonia gas. A better way is to keep the water in the burette slightly acid with sulphuric acid and use a little phenolphthalein to show that it remains so.

A third and less usual cause is in cases where much CO is present in the gases being analyzed, the cuprous chloride solution becomes so nearly saturated with CO that, while it will still absorb some CO from gas containing considerable CO, it will give up CO to a gas containing little or no CO, and in this way produce a negative reading, such as shown in Mr. Lowe's tables. This condition can be detected by analyzing a sample of air, in which case the amount of CO given up will be a measure of the amount going through the analysis undetected and the analyses can be corrected accordingly.

In fact, if one has a suspicion that the apparatus is not working just right it is a very convenient check to analyze a sample of air, for by comparing the results obtained with the true values of 20.9 per cent. oxygen and 70.1 nitrogen it is usually possible to tell what is wrong.

Newton Highlands, Mass. H. D. FISHER.

Countersunk Rivets on Boilers

In the issue of Apr. 1, under Inquiries of General Interest, someone asked if it was allowable to use countersunk nearly flush with the sheet.

I have worked in locomotive-repair shops several years and where the rivets are inside the firebox of locomotive boilers the use of countersunk rivets is quite extensive; in fact, on some, if not all, railroads the rivets inside the firebox are countersunk altogether, more especially along the side sheets and flue sheets. The mud-ring rivets are below the fire and they are not always countersunk, but quite frequently are.

It seems that the intense heat inside the firebox of this class of boiler burns off the heads if they are not countersunk nearly flush with the sheet.

In putting in a heavy flue sheet in the firebox the edge of the flange is generally scraped down quite a bit for the same reason, for if it is left very thick the heat injures it and makes it crack and leak all the more quickly.

Here is an incident which happened recently that may be of some interest: The boiler was being repaired and quite a few new stay-bolts had been put in the side sheet. When the boiler makers started to hammer up the stay-bolts the weather was pretty cold and the steel was cold. When they started to hammer the bolts the sheet cracked along a line between five stay-bolts, a length of about 22 in., making a new side sheet in the firebox necessary.

On examining the steel where it was cracked it had the frosted appearance of tempered tool steel when broken. It seems that the intense heat and strains on a firebox on a locomotive boiler tend to crystalize the metal and make it very brittle, as I have known of several such cases.

Livingston, Mont. HAROLD J. WILKINSON.

INQUIRIES OF GENERAL INTEREST

Lost Motion in Pump Valve Stem—What will be the effect of taking the lost motion out of the valve stem of a duplex pump?

F. M. S.

It will make the valve operate more promptly and result in shortening the stroke of the pump.

Adding Lap to Pump Valve—What would be the effect of adding lap to the steam valve of a duplex pump?

F. M. S.

It would have the effect of cutting off the steam before the end of the stroke causing the steam to act expansively for a short time as in an engine, and it would also delay the beginning of the stroke.

Cast-Iron Steam Pipe—Is cast iron suitable for underground steam piping?

J. P. S.

Cast iron has the advantage over wrought iron or steel of resisting corrosion better and hence is preferable for use underground, but it is a poor material for carrying steam of any pressure higher than 10 lb. per sq.in., because of the uncertainty of its strength and its behavior in expanding and contracting when subjected to variations in temperature.

Meaning of Name-Plate—The name-plate of a Worthington duplex steam pump patented Apr. 4, 1899, has the following size rating:

$$\frac{190 \times 216 \times 152}{7\frac{1}{2} \times 8\frac{1}{2} \times 6}$$

What does it mean?

J. E. M.

The upper figures are the metric equivalents of the lower ones. The pump has a 7½-in. (190 mm.) steam cylinder, 8½-in. (216-mm.) pump cylinder, and 6-in. (152-mm.) stroke.

Heating Water Electrically—What current and what size wire and how much of the wire would be required to raise the temperature of one gallon of water 10 deg. in 5 min.?

E. H.

From a table in Foster's Electrical Engineers' Pocketbook it is found that it will take 325 watts. At 110 volts this would mean approximately three amperes and a resistance of 36 ohms. A No. 20 iron wire has a resistance of one ohm for every 8½ ft. Therefore,

$$8\frac{1}{2} \times 36 = 306 \text{ ft.}$$

of No. 20 wire would be required.

Double Ported Duplex Pumps—Why is a duplex steam pump double-ported?

J. N.

To give separate passages for intake and exhaust of steam. The latter are not so near the ends of the cylinder as the steam ports are, so when the piston covers them no more steam can escape so that the piston is brought to rest without shock by the "cushioning on the exhaust." The steam thus imprisoned fills the clearance space back to the valve seat and when the valve opens the steam port at the beginning of the next stroke the clearance space does not require filling with live steam.

Life of Condenser Tubes—What is considered a reasonable length of life for condenser tubes using brackish water?

A. S. L.

The life will depend on local conditions. In one plant in the vicinity of New York where the condensing water is contaminated with sewage, the tubes last on an average of four years. At another plant where the water is acid the tubes have to be renewed on an average of every two and a half or three years. Another large New York plant reports a tube life of three years. All of these plants use aluminum-bronze condenser tubes, preferring them to those made of the admiralty composition.

Reversing Engine Rotation—How is the direction of rotation of a slide-valve engine reversed?

W. B. B.

Turn the engine over until the crosshead is at one end of its stroke and block the flywheel. The center of the eccentric will then be above or below the center of the shaft. Observe how far it is to one side or the other of the center and after loosening the eccentric revolve it around the shaft until it is the same distance from the center as before, but on the opposite side. Then remove the steam-chest cover and adjust the valve stem so the valve has the same lap over the steam port at each end.

Riding Cutoff—What are the advantages of having an adjustable riding cutoff on the low-pressure steam end of a cross-compound compressor?

R. R.

The adjustable riding cutoff equalizes or varies the relative amount of load carried by the high- and low-pressure cylinders, lengthening the cutoff on the low-pressure cylinder having the effect of reducing the proportion of power developed in the low-pressure cylinder, while shortening the cutoff in that cylinder increases the back pressure on the high-pressure cylinder and reduces the proportion of power developed in the high-pressure cylinder. A full explanation of the effect of changing the point of cutoff is given in the article "Shorter Cutoff, Greater Load," by F. R. Low, in "Power," Aug. 6, 1912, page 180.

Strain on Stay-Bolt—The outside nuts on a boiler stay-bolt are tightened until the strain is 8000 lb. in the body of the bolt. Then the inside nuts are tightened until the strain in the threaded part between the nuts is 2400 lb. Finally the boiler is put under 100-lb. pressure. What is the total load on the stay if each stay supports 100 sq.in.?

E. J. K.

The strain on the body of the bolt due to the boiler pressure would be

$$100 \times 100 = 10{,}000 \text{ lb.}$$

The initial strain being 8000 lb. due to the outside nuts, the body of the bolt will be under 18,000-lb. strain. The strain due to the inside nuts reduces no strains anywhere, but puts an added strain on the threaded parts of the bolt making the total strain at those points 20,400 lb.

Pump Capacity—How much water per hour will a duplex steam pump handle having a 6-in. steam cylinder, 4-in. water cylinder and 6-in. stroke, when making 75 r.p.m.?

W. H.

The cross-sectional area of the water cylinder, neglecting the area of the rod, is

$$4 \times 4 \times 0.7854 = 12.566 \text{ sq.in.}$$

The displacement for one 6-in. stroke would be

$$12.566 \times 6 = 75.396 \text{ cu.in.}$$

and for 150 (2 × 75 r.p.m.) strokes and two cylinders (the pump being duplex) would be

$$75.396 \times 150 \times 2 = 22{,}618.8 \text{ cu.in. per min.}$$

or

$$\frac{22{,}618.8}{231} = 97.917 \text{ gal. per min.}$$

or

$$97.917 \times 60 = 5875.02 \text{ gal. per hr.}$$

These figures do not take slippage into account.

Vacuum at High Altitude—How many inches of vacuum is it possible to obtain at an altitude of 10,500 ft.?

R. R.

At sea level the atmospheric pressure is 14.7 lb. per sq.in. At one mile, or 5280 ft. above sea level it is 12.02 lb. and at two miles, or 10,560 ft. it is 9.8 lb. Roughly the pressure decreases ½ lb. per 1000 ft. of ascent. For an altitude of 10,500 ft. (which is 10.560 — 10,500 = 60 ft. less than 2 miles) the pressure may be taken to be

$$\frac{60}{1000} \text{ of } 0.5 = 0.03 \text{ lb.}$$

less than 9.8 lb. or 9.77 lb. per sqin. As 2.0355 in. of mercury is balanced by 1 lb. of pressure, then with a perfect vacuum, an atmospheric pressure of 9.77 lb. would balance a column of mercury

$$9.77 \times 2.0355 = 19.887 \text{ in.}$$

and with good condensing apparatus it should be possible to maintain a vacuum of 19 in.

ENGINEERS' STUDY COURSE

Estimating Heat Value of Fuel

The heat value of a fuel is estimated either by actually burning a small sample and measuring the heat given off or by calculation based on either the ultimate or the proximate analysis. The first is the more accurate method, but as the cost of the required apparatus is rather high, and as it is not important for everyday work to know the exact heat value of every lot of coal received, we will pay most attention to the second method and pass over the first after giving a brief description in order that you may be familiar with it in a general way.

Coal Calorimeter

The sample burned is as carefully selected and prepared as the sample used for the proximate analysis, and its weight is usually the same, 1 gram. It is burned in a device called a calorimeter—a name derived from the words caloric, meaning heat, and meter, meaning measurer.

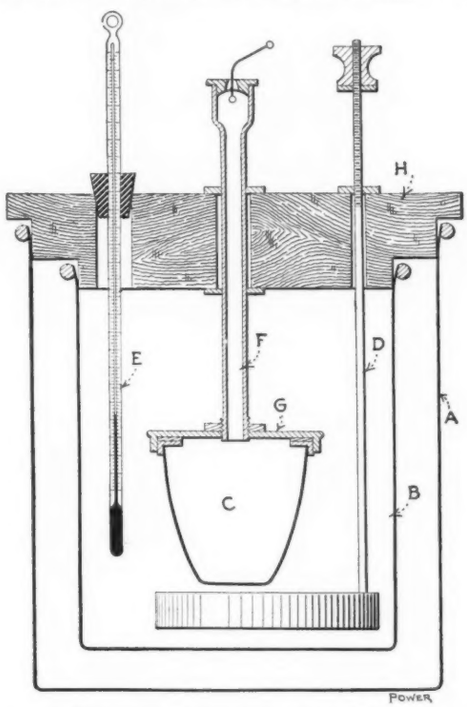


Fig. 1. Simple Form of Coal Calorimeter

Fig. 1 illustrates a simple form of the commonest type of coal calorimeter. The bomb or crucible *C* of iron or steel and lined with some material which is not affected by the products of combustion, contains the sample of coal to be tested, and is suspended in the water chamber *B* as shown. This water chamber is surrounded by the casing *A* to reduce error due to radiation. The stem *F* is hollow and closed off at the upper end by a valve. The wooden lid *H* is tight fitting. To load the bomb *C* it is taken out and unscrewed from the cap *G*. The sample of coal, thoroughly mixed with the proper amount of some chemical which gives up oxygen when heated (usually sodium peroxide) is put into the bomb and the latter is again screwed into place. A quantity of water, which has been exactly measured, is then put into *B*, and when the lid *H* is again fixed in place, the calorimeter is ready for the test. The water is stirred for a few minutes with the paddle *D* until the thermometer *E* shows that the temperature has ceased changing. Then the valve at the top of the stem *F* is opened, a small piece of red-hot nickel wire is dropped in and the valve quickly closed again.

Rapid and complete combustion takes place due to the liberation of the oxygen from the chemical mixed with the coal. The heat-laden products of combustion are all trapped in the bomb and hence must give up their heat to the surrounding water, which is again stirred for several minutes to hasten the transfer and to maintain uniformity. The rise in the temperature of the water is carefully noted, the thermometer being graduated to read in small fractions of a degree.

Knowing the weight of the water and the rise in temperature, the number of heat units generated by the sample can easily be calculated by multiplying these two factors together, and the heat value of a pound of fuel can then be found by multiplying by a constant, which takes into account the ratio of weights and other factors involved.

Heat Value by Calculation

As has been pointed out, the combustion of a given element always results in the generation of a fixed amount of heat. Thus, when a pound of pure carbon burns completely (forming CO_2) 14,600 B.t.u. is produced. When 2 lb. is burned, 29,200 B.t.u. is generated, and so on. Consequently, the heat value of carbon is said to be 14,600 B.t.u.—which means 14,600 B.t.u. per lb., as the pound is the unit of weight almost universally used in this country.

When a pound of pure carbon burns incompletely (forming CO), only 4450 B.t.u. is produced. But if, in turn, the resulting $2\frac{1}{3}$ lb. of CO., which is a combustible gas, is burned, 10,150 additional B.t.u. is liberated, making the total heat produced equal to 14,600 B.t.u., just the same as though the pound of carbon had burned completely (to CO_2) in the first place. Hence, the heat value of CO is

$$\frac{10{,}150}{2.333} = 4350 \textit{ B.t.u. per lb.}$$

The heat value of pure hydrogen is 62,000 B.t.u. per lb.

These heat values for carbon and hydrogen were established by experiment and hence probably are not absolutely exact. In fact, some authorities give values for carbon as low as 14,220, and as high as 14,647, and for hydrogen as low as 61,816 and as high as 62,032, but as the ones given (14,600 and 62,000) are the most widely accepted and used, it is best to accept them for use in our work.

The heat value of sulphur, the only other heat-producing element in the common fuels, is 4050 B.t.u. per lb. While this fact is interesting, it is not important in practical work, because in addition to the heat value of the sulphur itself being low, the percentage of sulphur in the average fuel is also low; besides, the sulphur may not be pure and hence may have no heat value whatever. Thus the amount of heat due to the sulphur is very small compared with that given up by the two main elements, carbon and hydrogen.

To estimate the heat value of a pound of fuel containing both carbon and hydrogen, simply multiply the percentage of total carbon in the fuel (expressed as a decimal) by 14,600, the percentage of available hydrogen (also expressed as a decimal) by 62,000 and add the results together.

To illustrate, assume we wish to estimate the heat value of a coal with this analysis: Carbon, 68.12 per cent; hydrogen, 4.98 per cent.; oxygen, 7.42 per cent.; nitrogen, 1.98 per cent.; sulphur, 4.54 per cent.; ash, 12.96 per cent.

The heat due to the carbon is

$$0.6812 \times 14{,}600 = 9945.5 \ B.t.u.$$

The available hydrogen equals

$$0.0498 - \frac{0.0742}{8} = 0.0405$$

and this, multiplied by the heat value of hydrogen,

$$0.0405 \times 62{,}000 = 2511 \ B.t.u.,$$

the heat due to the hydrogen in the coal. The sum of these two quantities is

$$9945.5 + 2511 = 12{,}456.5 \ B.t.u.$$

the heat value of the coal.

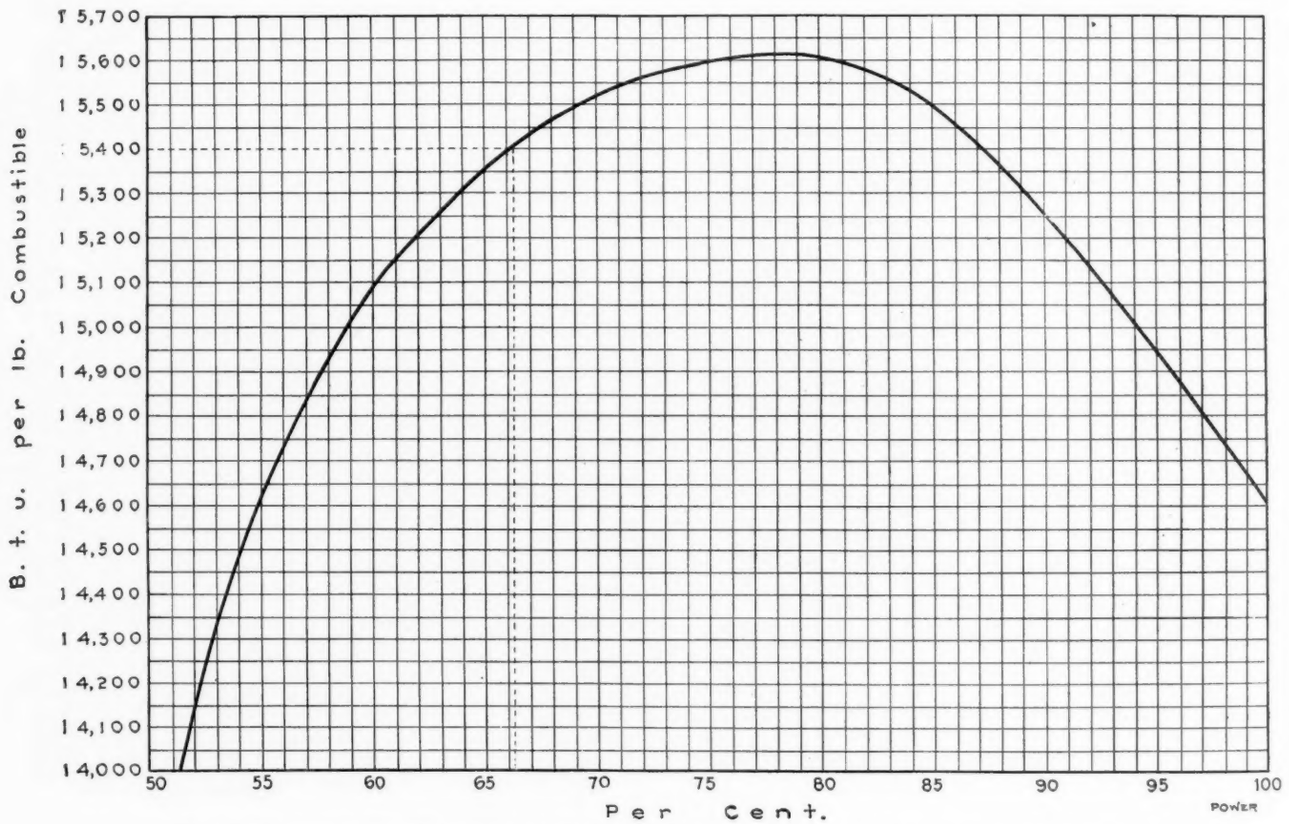


FIG. 2. DIAGRAM FOR ESTIMATING HEAT VALUE OF COAL FROM PROXIMATE ANALYSIS

HEAT VALUE BY FORMULA

The foregoing method can be expressed in a formula as follows:

$$C \times 14{,}600 + \left(H - \frac{O}{8}\right) 62\,000 = B.t.u. \ per \ lb.$$

where

C = Decimal part by weight of carbon in the fuel;
H = Decimal part by weight of hydrogen in the fuel;
O = Decimal part by weight of oxygen in the fuel.

To apply this formula to another example, assume a coal with this analysis: Carbon, 65.23 per cent.; hydrogen, 4.95 per cent.; ogygen, 14.85 per cent.; nitrogen, 1.66 per cent.; sulphur, 2.10 per cent.; ash, 11.21 per cent. Substituting in the formula, we have

$$0.6523 \times 14{,}600 + \left(0.0495 - \frac{0.1485}{8}\right) 62{,}000$$

$$= 11{,}439 \ B.t.u.$$

The foregoing method or formula may be used for any other kind of fuel or for oil, wood, gas, etc. In dealing with gas, however, care must be used that volumes and weights are not confused to produce error. A common method of stating the heat value of a fuel gas is in B.t.u. per cubic foot or per 1000 cu.ft. In such cases the temperature and pressure of the gas must also be specified because these influence the volume greatly. The temperatures most frequently taken are 32 and 60 deg. F., and the pressure, 14.7 lb., absolute.

HEAT VALUE FROM PROXIMATE ANALYSIS

The proximate analysis of coal does not give the percentage of hydrogen, the percentage of oxygen nor the

percentage of total carbon. It does give the percentage of fixed carbon, but in addition to this the fuel contains some carbon which forms part of the volatile matter and the amount or percentage of this volatile carbon cannot be found except by the ultimate analysis. Hence, the formula just given is of use only in those few cases where the ultimate analysis is available, so that other methods will mostly have to be used in our work.

Some relation exists between the percentage of fixed carbon in the combustible matter of coal and the heat value of the combustible matter. To illustrate, if the combustible matter of a given coal consists of, say, 60 per cent. fixed carbon and the other 40 per cent. volatile matter, it is probable that the heat value of a pound of such combustible matter will be found to be about 15,080 B.t.u. This does not apply closely to all coals, but it applies closely enough to most coals to be useful in the absence of a better or more accurate method of estimation that can be used with the proximate analysis.

Fig. 2 is based on this fact. This chart was constructed from over 300 analyses, representing coal found in 27 states and territories, made by the United States Government and published in numerous bulletins. It is almost exactly correct for a limited number of cases, reasonably near correct (probably within 3 per cent.) for a large number of cases and quite far from correct in a few cases. The curve is most uniformly accurate for coals which have combustible matter containing from 64 to 90 per cent. fixed carbon. Where the fixed carbon runs less than 64 per cent. the curve may, in a few cases, err as much as 7 per cent.

Application of Chart

To estimate the heat value of a coal with a given proximate analysis, add together the percentage of fixed carbon and the percentage of volatile matter in the coal; divide this sum into the percentage of fixed carbon and multiply by 100. This gives the percentage of fixed carbon in the combustible matter. Locate this percentage at the foot of the chart, extend your pencil straight up until you strike the curve, then extend it to the nearest (left or right) margin in a straight horizontal line and read off the B.t.u. per pound of combustible. Multiply the B.t.u. thus found by the sum of the percentage of fixed carbon and volatile matter in the coal as shown by the proximate analysis, and the answer, divided by 100, gives the B.t.u. per pound of coal.

To illustrate with an actual example, assume a coal with this proximate analysis: Moisture, 5.12 per cent.; volatile matter, 27.25 per cent.; fixed carbon, 53.38 per cent.; ash, 14.25 per cent. Adding together the percentage of fixed carbon and the percentage of volatile matter,

$$53.38 + 27.25 = 80.63.$$

Dividing this into the fixed carbon, we have

$$53.38 \div 80.63 = 0.662,$$

which, multiplied by 100, gives 66.2 per cent. fixed carbon in the combustible. Referring to the base line of the chart, find the 66 per cent. line and judge a point 0.2, or $\frac{1}{5}$, of the distance to the next line beyond. Trace an imaginary vertical line (this line is shown dotted on the chart) up from this point to the curve and then horizontally to the left margin. It strikes exactly the 15,400-B.t.u. line. Then, 15,400 B.t.u. may be taken as the heat value of a pound of combustible matter such as found in the coal given in the example.

Now, if the coal was all combustible and had no moisture nor ash, the heat value per pound of coal would be identical with the heat value per pound of combustible. But only 80.63 per cent. of the coal is combustible, and hence the heat value of a pound of coal is equal to only 80.63 per cent. of the heat value of a pound of combustible. Thus, the heat value of the coal is

$$15,400 \times 80.63 \div 100 = 12,417 \ B.t.u.$$

Exercise Problems

What is the heat value of a coal with the following ultimate analysis: Carbon, 63.65 per cent.; hydrogen, 5.26 per cent.; oxygen, 10.12 per cent.; nitrogen, 1.59 per cent.; sulphur, 5.03 per cent.; ash, 14.35 per cent.?

Estimate the heat value of a coal which has this proximate analysis: Moisture, 1.36 per cent.; volatile matter, 35.51 per cent.; fixed carbon, 50.06 per cent.; ash, 13.07 per cent.

NEW PUBLICATIONS

BERECHNUNG, ENTWURF & BETRIEB RATIONELLER RESSELAUHAGEN (Calculation, Design and Operation of Rational Boiler Plants). By Max Geusch. Published by Julius Springer, Berlin, Germany. Cloth, 6x9 in.; 207 pages; 95 figures. Price, $1.50.

Although steam-boiler design has been developing for so many years much improvement can still be made in the various parts of a boiler plant. The object of this book is to show how such improvements can be accomplished, if the designer will accept better information about the processes involved in steam production. In his preface, the author points out why he contends we have not advanced far from the first stage of boiler design, although marked improvements have been made in economy. This, he maintains, is clearly perceived if we look at the present status of boiler design and the every-day specification of their form, etc. We can expect to make considerable progress only through a careful development of the theories involved.

This book is, therefore, highly theoretical and can only be used by persons possessing a thorough knowledge of higher mathematics. It is arranged very concisely and clearly without going far into details of existing boiler types. The subject is treated rather from a general point of view.

In the first chapter, "The Furnace," the author makes an exhaustive study of all factors involved in building an efficient furnace. The questions of fuel, air supply, flue gases, radiation, etc., are carefully analyzed and practical examples help to explain the complicated formulas. With like carefulness the heating surface is treated in another chapter. The importance of rightly proportioning the heating surface is shown and the development of steam, the capacity of the heating surface, water circulation, etc., are exhaustively treated. A special chapter is devoted to the draft, since the economy of a boiler plant is largely dependent on a careful dimensioning of the flue and stack. The contents of this chapter ought to be of great value to the designer. Formulas are given by means of which good results can be obtained. Practical examples show the usefulness of these formulas. The final chapter is devoted to the general erection of boiler plants. It is very important, as it deals with the problems involved in selecting boilers, furnaces, economizers and superheaters. Space is also devoted to controlling devices, such as those for determining the daily coal consumption, flue-gas analyzing apparatus, etc.

This book should prove of great use not only to the constructor and student, but also to the user of boiler plants.

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In erecting the 80-ft. sheet-iron smokestack at the new boiler plant of the Belle-Vernon-Mapes Dairy Co., Cleveland, Ohio, a three-ton motor truck was made to serve as a hoisting engine. The stack weighed nearly 4500 lb. and had to be elevated to a masonry foundation 12 ft. above the ground surface. A guyed mast was set up alongside the base of the stack; a cable, made fast to the stack, was carried through a pulley at the masthead, down to a second pulley near the ground and thence to the motor truck. The truck then was backed away from the mast and the stack hoisted until it could be swung around and lowered into position on its foundation. The operation consumed only a few minutes.

Engine-Cylinder Lubrication

By Willis Lawrence

SYNOPSIS—It is pointed out that a high-priced oil is not necessarily the best oil for steam-engine cylinder lubrication, also that the moisture content of the steam, a most important factor in selecting a good oil, is too often a matter of mere guesswork. Graphite combined with oil proves a good lubricant for engine cylinders.

When supplies are purchased for the steam plant, some known standard of quality is employed to ascertain the plant value of the supply, or the composition of the material is learned and the known value of the constituents give to the supply its value. In the buying of coal the British thermal units, ash, carbon, etc., fix the value. The value of metals is governed by their composition;

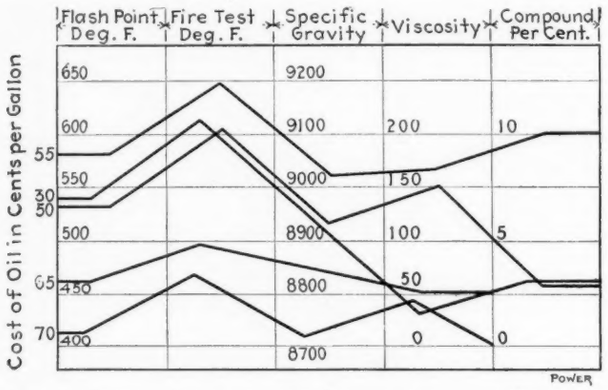

Fig. 1. Test Results of Various-Priced Cylinder Oils

textiles by their fibers, weave, etc., but in the selection of a cylinder lubricant such methods are rarely employed, although the selection of a suitable oil, owing to its influence on the maintenance and operating costs, demands more critical attention than is usual in power-plant practice.

A common occurrence when trouble appears in the form of scored cylinders and valves, is to hold the oil responsible for the damage. After the necessary repairs are made and possibly the mechanical cause of the trouble removed, another oil is substituted with very satisfactory results. Both oils may have come from the same field, had the same composition and physical properties, in fact, be the same oil, but from barrels with different trade names, and the admiration for the second, together with the condemnation of the first, would be unjustified. Most engineers do not compare the physical properties of the oils to learn which one possesses the most desirable constituents for his particular needs, but is satisfied to continue with the oil which operates the engine without any outward appearance of trouble.

This condition works a hardship on the oil seller as well as on the oil user, as it does not place the buying of oil on a safe competitive basis. The honest salesman who is anxious to submit his wares for competition based upon their composition and characteristics is often shut out, while inferior goods at high prices are admitted to the plant, working an injustice to the producer and consumer.

Should an engineer for any cause be compelled to change the cylinder oil through its failure to give desired results, he would naturally look for a better oil This might mean a more suitable oil for his requirements at a lower cost, or different composition at the same cost. Not knowing the values of the different constituents he will generally buy a higher-priced oil with the result that he may possibly get an oil inferior to that which he was using, judged from the point of plant valve.

Fig. 1 shows curves plotted from analyses of different oils ranging in price from 30 to 70c. Considering that oil having the higher flash and fire test with the proper compounding as being the most suitable for steam-cylinder lubrication, we are forced to the conclusion that the plant values of these oils are in inverse proportion to their prices. The lower lubricating values represented by the curves are for gas-engine cylinder lubrication, which demands a more fluid oil with absence of carbon-producing matter. They usually represent an earlier stage of distillation and probably cost more to produce, due to the filtering process, but the increased cost of production does not seem to be sufficient to justify the higher prices quoted. It will be seen that had the engineer selected an expensive oil he would have undoubtedly received a lubricant entirely unsuitable for the steam cylinder. We must select an oil free from tar and similar

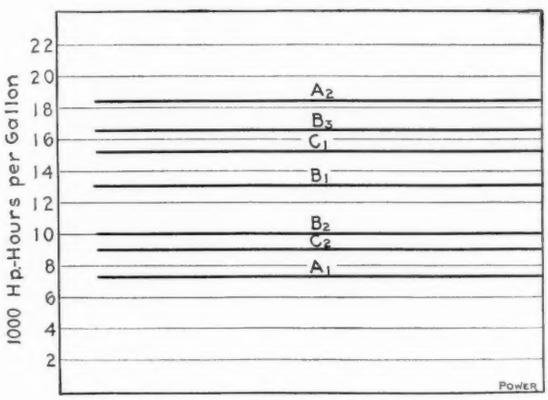

Fig. 2. Results of Tests of Cylinder Oils

bases, which forces us to the Pennsylvania crude oil. This product is almost entirely free from these heavy carbons and has a paraffin base. When the refinement is carried to the point where the oil burns at 600 or 650 deg. F., and contains sufficient acidless tallow to form an emulsion with the moisture in the steam, we have the standard high-grade steam-cylinder oil. It will be seen that the influence of the oilman is limited, and is usually confined to compounding the oil to meet the moisture conditions. In this he is compelled to rely upon the engineer's report, who in turn is usually without the necessary means to accurately determine the amount and he is compelled to guess at the proportion. If the salesman accepts the report as being correct, he compounds the oil accordingly. It will be seen, then, that one of the most important constituents is proportioned by guess, and this condition explains the trouble sometimes encountered in securing the proper oil to meet the plant requirements.

The "old hand" at the business, when trouble is re-

ported at a certain plant, rushes to it with an oil high in tallow, often as much as 12 per cent. and invariably produces an improvement in conditions, and after securing the business proceeds to lower the animal matter to a reasonable amount. The foregoing conditions are illustrated in the curve, Fig. 2, where three oil companies competing for the plant's business put forth their best efforts to secure the highest efficiency for their oils.

A on his first attempt secured 7500 hp.-hr. per gal. followed by 18,500 hp.-hr. on the second trial. B's first trial resulted in 13,000 hp.-hr., the second in 10,000 hp.-hr. The third trial went to 16,500 hp.-hr., while C's efforts secured 15,500 and 9000 hp.-hr. respectively. It is obvious that if their products had been compounded with a reasonable degree of certainty the results would have been more certain.

After experimenting with similar conditions the writer is confident that graphite properly administered would have given all the oils nearly the same value, and would have raised that value much higher than those obtained.

It will be seen that the greatest and most important task in meeting severe lubricating requirements is to mix with the clean base oil the required amount of animal fat. It might be added that this point must be located between very narrow limits, as an insufficient amount fails to give the required lubrication, while an excess results in boiler troubles, insulation of condenser tubes, the formation of deposits in the steam spaces, and chemical action on the steam surfaces of valves and cylinders. The troubles and the difficulty experienced in attempting to meet the usual superheat conditions resulted in a series of experiments to determine the value of graphite or some more stable lubricant to assist the cylinder oil to meet the varying conditions without resorting to the use of animal fats, which, as stated, requires a delicate proportioning to meet the moisture conditions, and which are valueless in dealing with the superheat conditions. If it should meet these conditions, it would still have the objections described.

Tests were arranged to determine:

First. The mechanical action of graphite on the steam surfaces.

Second. If its use produced any injurious action on the cylinder walls.

Third. Its influence on the efficiency of cylinder oil and consequent effect on the cost of lubrication.

Fourth. If its use would produce deposits in the oil grooves and ring slots of piston valves, etc.

Fifth. If it could be substituted for the animal fat and thereby eliminate the uncertainty of compounding and the objectionable features of the tallow.

Sixth. If any injurious effect would be produced in the boilers if carried back by the condensate.

The first test was to take a sample from a highly-polished cylinder which had been operated with a high-quality cylinder oil, which under the microscope showed a rough surface with not more than 25 per cent. of the area as effective surface. This condition was the result of the usual porosity of the iron together with the tool marks. The same cylinder was then lubricated with graphite and oil for two months and another sample examined with entirely different results. The interstices of the iron had been filled with graphite and the surface covered with a film of it. The action resulted in filling up the low section of the iron and thereby increasing the bearing surface. The depressions acting as reservoirs took the graphite from the steam and gave it up to the piston as it passed over it, producing a very substantial low friction surface to support the moving parts.

The iron was then subjected to an oxygen flame in which the graphite became incandescent, showing very plainly its presence and distribution throughout the metal. A thorough examination failed to reveal any objectionable conditions in the cylinder and this has remained true through two years of operation.

To determine the efficiency of amorphous graphite as a lubricant, a high-pressure cylinder of a compound engine having excessive lap and using high-pressure steam was used. By feeding the minimum amount of oil necessary to lubricate the cylinder, a value was determined by the number of hours the engine would run on a gallon of the oil. After repeated trials it was found that the values ran from 6 to 12 hr. per gal. with what might be considered standard high-grade oils. The same oils treated with graphite gave an almost uniform value of 22 hr., equivalent to an increase of 83 per cent. This figure was very closely approached in regular operation, as may be seen by observing the curve, Fig. 3. The lower part of the curve represents the average of three months' consumption of oil without graphite and fed with hydrostatic lubricator, while the upper part shows the effect of oil with graphite, using an improved lubricator. The increase is approximately 139 per cent. The same effect is illustrated in Fig. 4. The upper line represents a month's consumption of oil with hydrostatic lubricators. The middle line represents the same condition with a small amount of graphite, while the lower line was produced during the third month with sufficient graphite and an improved method of feeding, i.e., preventing settlement of the graphite in the oil.

To test the durability of graphite as a lubricant the engine was lubricated with cylinder oil for a few days,

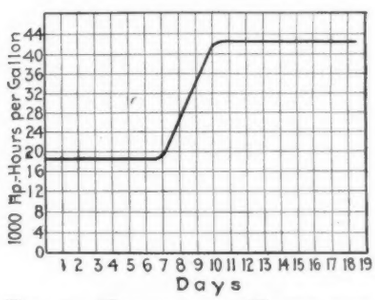

FIG. 3. HORSEPOWER-HOURS PER GAL. WITH AND WITHOUT GRAPHITE

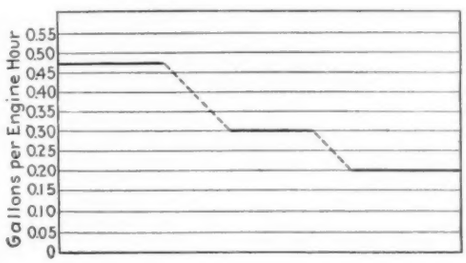

FIG. 4. SHOWING DECREASE IN OIL CONSUMPTION

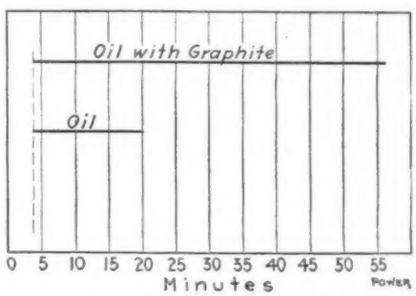

FIG. 5. TIME ENGINE RAN WITHOUT LUBRICANTS

then the supply of oil was suddenly stopped. After 20 min. it was necessary to reëstablish lubrication. The same experiment with the graphite mixture enabled the engine to run 57 min. before lubrication was again necessary. This is graphically shown in Fig. 5, where the difference in the two lines represents the difference in the durability of the two methods.

The question of deposits was taken up by collecting samples of accumulation from low-pressure cylinders, gas engines and every place where graphite has been used. In some cases the engineer had emphatically stated that the deposit was the result of the use of graphite, but in no case was graphite found to be present more than by 12 per cent., and mostly at an average of 7 or 8 per cent., the balance being animal matter, iron and sand with some carbonized oil.

Curve *A*, Fig. 6, represents the action of oil without animal fat. After the effects of previous graphite lubrication had disappeared, the value of the oil fell very

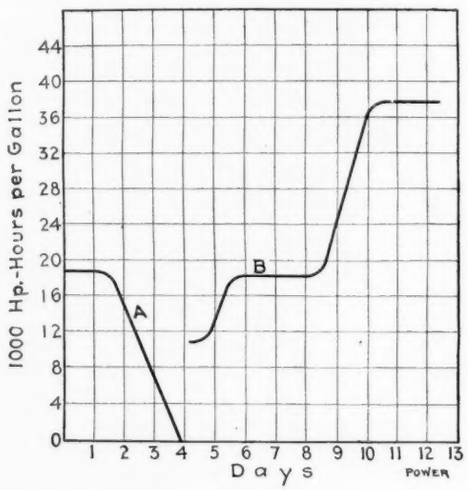

FIG. 6. ACTION OF OIL WITHOUT ANIMAL FATS AND OF SAME OIL TREATED WITH GRAPHITE

rapidly. On the fourth day it became necessary to discontinue its use, even though large quantities of the oil were being fed. Upon examination the valves showed indication of cutting. The same oil was then treated with graphite, which not only corrected the previous conditions but gave very satisfactory lubrication at high efficiency, as is shown by the curve *B*.

To test the effect of graphite on boilers, 200 lb. of graphite was introduced with the feed water for a period of three months without producing anything but beneficial results.

The results of the experiments justify the opinion that the action of graphite on steam surfaces is mechanical and positive, producing much better lubrication than can be obtained by the use of cylinder oil alone. Also, that no injurious action results from its use either in engine cylinders or the boilers, and, further, that its use increases the efficiency of cylinder oil from 40 to 100 per cent. That deposits will not form any more rapidly than when cylinder oil containing animal fat is used. In most cases the graphite can be substituted for the animal fat, when a constant mixture of it and cylinder oil in predetermined proportions is fed to the cylinder.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The "Engineering Record" says that the engineer is best fitted for the work of mosquito extermination. At last we find a practical meaning for the "M. E." so often tacked on the end of the engineer's name: Mosquito Exterminator! Go to it, M. E.; swat 'em!

❖

No corporation can remain soulless after Doctor Cupid gets his strangle-hold on it. The Georgia Ry. & Power Co. has fallen under the wiles of this heart specialist, who prescribes matrimony as an efficiency tonic for its employees. A single man may now have his Sunday afternoons off in an endeavor to decrease the visible supply of old maids. Getting married is hard work, but the way you have to hustle afterward makes you forget it to some extent.

❖

For doggone meanness, nothing equals those swindlers who, under the name of "college," rob young men of their savings by inducing them to take a course in their "colleges." "Leslie's Weekly" says there are several fake institutions carrying on such work. It's not difficult to get the endorsement of people who know the standing of a reputable school, and you don't have to take the school's say-so, either.

❖

Some 50 years ago a paper was published in New York called the "Quadruple Constellation." It was only 24 pages, but the size of them, as Cassidy said, would paper a house. The sheets measured 70 by 100 in., divided into 13 columns, each 48 in. long. The editor intended publishing it every hundred years. It took 40 people eight weeks to compile it. This sounds like a joke, but it's an historical fact; a man in Philadelphia has a copy. By the time he gets issue No. 2 he'll have to build a garage to keep the two of them on file.

❖

SOME REFLECTIONS ON THE WATER

Editor the Spillway:

Sir: Of course you have come in more or less contact with water. Have any confidence in it? Do you respect it? Well, I don't; leastwise Croton water. It's chock full of "thallogenous, chlorophyllous cryptograms." By patient research you will find that this unpronounceable mess is algae, or seaweed. I don't hanker for a drink that demands the use of the slicebar to break it up before it will flow freely.

Seaweed is a food, a recreation, may be. Mixed with H_2O, it's a good reason for a $10,000 suit against the editor who says you use it promiscuously. I take my seaweed plain, unfiltered and externally, down to the seaside.

Along about July, on my day off, I hie me to the shore, modestly array myself in the bathing habiliments my fond wife thinks so becoming, and sportively plunge into the briny deep. It's then I get my seaweed and water. Sometimes I get more than this. If the tide is low I may come to the surface in the warm embrace of a pair of last season's corsets, or closely attended by a badly worn watermelon. (One summer I collected beer-bottles—with the soles of my feet.)

On rare occasions I have, for a brief interval kept company with a deceased feline or a more or less perfectly good dog that, despairing of my coming some six weeks before, gave up his young life and just patiently floated around loose in the meanwhile—admitting that a dog can become loose in the meanwhile. Draped in sufficient seaweed, with a blue or green background of salt water, these surroundings are merely picturesque if you don't take a day off too often.

And no one would for a moment intentionally accept any of these incidentals internally. They are honest, they make no pretense of being other than they are. But this Croton stuff basely steals unawares into our very midst; it travels under false pretenses. Masked by seaweed, Croton may contain pollywogs or molligoggles, embryonic lizards or juggledoogers. Who knows? Who seems to care?

Even as a chaser, you can't be too particular about what you drink. Admitting that you abstemiously take a chaser, it's fearful to think that perhaps even this very minute you are a traveling aquarium or a human jar full of the aforementioned pernicious little cusses preserved in alcohol.

Seaweed, or algae, help yourself, is an excellent fertilizer, sir; it raises things, garden sass and vegetables. Croton, sir, raises my indignation.

Yours for better conditions.

ALGAE C. WEED

MEMBERS OF THE NATIONAL DISTRICT HEATING ASSOCIATION ON THE ROOF OF THE CLAYPOOL HOTEL, INDIANAPOLIS, IND.

Heating Engineers Meet at Indianapolis

At Indianapolis and in the Claypool Hotel, on May 27 to 29, inclusive, the National District Heating Association held its fifth annual convention. The registered attendance was 150, and all were enthusiastic over the best meeting in the history of the association. The papers were good and varied in character, the exhibits were better than usual, and the efforts of the entertainment committee were highly appreciated.

Hon. C. A. Bookwalter welcomed the visitors and in the course of his address referred to central-station heating as the solution of the smoke problem. In the response Secretary Gaskill pointed out that Indianapolis had the largest central-heating system in the world.

In his address President De Wolf spoke of the work of the association and outlined a number of topics that it would be well to investigate. Losses in transmission lines need to be studied more carefully, economical methods of operation by the consumer should be devised and their importance brought to his attention, more uniformity in specifications was required, and it was the president's opinion that a cheaper method of carrying heavy peak loads was entirely practical. He emphasized the importance of central stations being prepared to give heating service, so that they might fully take the place of the private plant. Reference was made to the work of the various committees and in some instances their continuance recommended.

The secretary's report showed a net gain of four in the membership, making a total of 229. The destruction of the 1912 proceedings during the recent flood, entailing a loss of $400, was brought before the convention, and before the close of the meeting the full amount was subscribed. Routine business and the report of the committee on meters occupied the balance of the morning session. S. Morgan Bushnell, chairman, read the report which was more or less supplemental to the report of the 1912 committee. A number of meters of different type than those in last year's report were described, defects in present meter construction were pointed out, rules for the care and maintenance of some of the different types of meter were prepared, and an outline of meter department routine in a heating company was given. Another subject taken up by the committee was that of meter vs. flat rates for steam service. It was this part of the report which was subjected to a lengthy discussion.

E. Darrow, general manager of the Merchants Heat & Light Co., of Indianapolis, favored flat rates. Meter service tends to develop a peak at practically the same time as the electric service, so that the demand on the station is intensified. At his plant both the electric and heating peaks came from seven to eight in the morning and four to six in the afternoon. The flat-rate service uses the equipment throughout the 24 hr. fairly equally and tends to fill up the valleys. On the system, however, automatic regulation maintains the temperature at 70 deg., and with this control from the power house, the steam consumption need be no more and may be less than would be required by a metered service.

A number of interesting discussions followed and all favored meter service. In one case cited, a change from flat rate to meters had increased the revenue 50 per cent. and cut the coal bill in half. In another case the saving in steam consumption was estimated at 15 to 20 per cent. With no station control of temperature, meters will without doubt effect a considerable saving and especially after the customers have learned how to regulate their services. With the system automatically controlled, a reduction of pressure and temperature rather than cutting off the steam is the proper solution of the problem. A. C. Rogers, of the Toledo Railways & Light Co., had found this method more economical and in subsequent discussion was confirmed by Mr. Darrow.

The educational committee, E. F. Capron, of Chicago, secretary, presented a code pertaining to important points in the installation of heating and ventilating plants, suggesting that the association coöperate with the American Institute of Architects, American Society of Heating and Ventilating Engineers, and the American Society of Mechanical Engineers.

"District Hot-Water Heating for Residences" was the title of the first paper, which was read by A. C. Rogers. The author arranged the paper under five general heads including Circulation, Radiation, Placing of Radiation, Water Temperatures and Atmospheric Conditions. Under the first heading sizes of piping, covering, valves, air pockets and air vents were touched upon. For determining the proper amount of radiation there were numerous formulas which gave as many different results. The author took a five-room plan and using thirteen formulas given in the paper, tabulated the results. A variation from the average as high as 40 per cent. was obtained. The water temperature depends a great deal on the amount of radiation installed. A table giving the

schedules of four different companies showed considerable variation for the same outdoor temperatures. The fifth division of the paper was devoted to humidity and wind.

N. M. Argabrite read a paper on the "Possibilities of Hot-Water Heat." In his opinion the greatest possibilities lie in improving and bringing up to date present systems by removing some of the wasteful auxiliaries, getting rid of open heaters and installing heater condensers so that the power end will have the advantage of the vacuum, installing thermostatic control for the consumers, improving the pipe insulation and reducing the steam consumption of the pumps by driving them electrically, the rate being approximately that of the main unit. In his plant the author ran one unit on the heating system, getting whatever vacuum the temperature of the water would permit. The balance of the electric load was run full condensing. Regulation of the water temperature was effected by shifting the electrical load, that is, in moderate weather the load on the unit carrying the heating is reduced, so that with less steam the temperature of the water can be maintained at a lower point. The author did not favor increasing the circulation and preferred the method just outlined to that in which the electric load is maintained and the vacuum adjusted to obtain the proper temperature for the water. Rates were given brief mention and the author made a strong point on increasing the electric load even at a reduction in rate so that there would be plenty of steam for the heating.

At the end of the afternoon session the nominating committee reported. The following officers were unanimously elected: President, S. Morgan Bushnell; first vice-president, E. Darrow; second vice-president, H. R. Wetherell; third vice-president, D. S. Boyden; secretary-treasurer, D. L. Gaskill; executive committee, C. F. Oehlman, W. A. Wolls and R. D. DeWolf.

On Wednesday morning, A. B. Biggs read the report of the committee on station records, telling why records were necessary and giving the following summary of those most useful.

1. Monthly and yearly cost report on all branches of operation: Thousands of pounds of steam sold. Tons coal consumed, price per ton and total fuel cost. Labor cost. Total operation cost. Operating cost per thousand pounds of steam sold. Total maintenance cost. Maintenance per thousand pounds of steam sold.

2. Monthly report showing: Amount of steam used. Amount of radiation added and cut out. Number of feet of mains and service laid. Number of meters set and removed.

3. Meters: Complete record of all tests and repairs.

4. Cubical contents: Exposed wall and glass, amount of radiation installed and amount required for all buildings connected to mains.

5. Mains and services installed: Size, length, square feet of heating service and exact location of pipes and fittings.

In the discussion, Mr. Boyden pointed out that it was specially important to keep a record of the exhaust steam and also of the live steam used in the system. Then by subtracting the meter readings the unaccounted for steam would be determined and it would be an easy matter to accurately compare the operation of different plants.

N. M. Argabrite thought analysis of operation a most important factor. In the plants belonging to his company close records of coal and water and data on draft and load were kept, so that it was possible to know exactly at any hour of day what each department was doing. In addition a bulletin containing the records was sent out every two weeks so that the different plants could compare results.

"Recent Improvements in Boiler-Plant Design and Operation," by Norman C. Reinicker was the next topic. Of the many radical changes made in boiler-room practice during the last few years, the greatest has been the installation of large boiler units such as those now in commission at the Delray plant of the Detroit Edison Co. Seven "special" type W 2365-hp. Stirling boilers are now operating and two more are in process of erection. These large boilers are just as reliable as smaller units, more efficient and it is possible to operate one side with a reduction in capacity of only 40 per cent. In practice these boilers have been operated efficiently over a range of from 50 to 225 per cent. of rating.

Another change in boiler-plant practice in the last few years has been the perfection and general acceptance of the underfeed type of stoker for high-grade bituminous coals. More attention is being paid to coal analysis, boiler-room instruments are being improved, electric motors in the boiler room are replacing steam-driven auxiliaries, the centrifugal boiler-feed pump is replacing the old duplex type and feed-water regulators are being perfected to give continuous feed. Results of changes of baffles in Stirling boilers made at the Delray plant during the last year were discussed. With the improved baffling slightly greater efficiency was obtained and considerable decrease in repairs to brick walls. A short discussion on bleeder turbines followed.

S. M. Bushnell, the newly elected president, then addressed the convention briefly. He spoke of the better work that can be done by small organizations. For this very reason the larger associations divide up into sections. He had heard no talk of the present organization combining with some larger society, and it was his hope that they would continue in the same way carrying on the good work that they had done in the past. Discussion on changes in the constitution, reclassification of some of the members, raising the dues, and raising the funds to cover the loss by flood took up the balance of the morning session.

On Wednesday afternoon, H. W. Prentis, Jr., of the Armstrong Cork Co., gave a very interesting talk on the insulation of underground pipe lines, which was illustrated by a series of lantern slides.

G. E. Quinan spoke at length on the power plants and heating business of the Puget Sound Light & Power Co., of Seattle, Wash. The company has a total of 500,000 sq.ft. of radiation which is supplied with live steam reduced to a pressure of 5 to 10 lb. at the plant, as most of the electrical load is generated by water power. The report was full of interesting facts and was highly appreciated.

Secretary Gaskill, in his paper on "Commission Control of Public Utilities," spoke highly of the state commission, the requirements for proper control, and the better feeling between the utility and the public after a competent commission has had a few years' experience and has been given ample funds and power.

"Appraisal of Heating Properties," by Harold Almert, followed and both papers were discussed on Thursday morning. Mr. Almert spoke mostly on legislation calling for inquiry into, or the restriction of, profits earned by public-service corporations. He dwelt upon the ignorance of many legislators on the operation of public utilities and the limitations of the commissions appointed. He urged every company to carefully analyze its own situation and if time or talent were not at hand, engineering firms of recognized standing could be retained to make a careful and comprehensive appraisal. Real indisputable facts as a fortification against the council or commission are wanted and it pays to select competent experts to get them. During the discussion, Mr. Almert thoroughly explained "going value," and some time was given to the attitude of the commissions toward electric and heating companies.

"Is District Heating Profitable to the Central Station?" This was the question allotted to C. J. Davidson, and in his paper he analyzed in part the divergency of opinion between the public and the central-station men. The public think that the gross receipts are on the credit side of the ledger, as the exhaust steam used is a byproduct which otherwise would be wasted. General opinion among central-station men is to the effect that there is no money in the heating business. A number of cases were cited to support the latter view. The conditions under which a power plant can advantageously supply heating service were discussed from the power-plant end, the street mains, and from the standpoint of rates.

A short discussion followed on the corrosion of cast iron, wrought iron and steel pipes. D. K. Mason, of the National Tube Co., cited an investigation by Dr. W. H. Walker, of the Massachusetts Institute of Technology to show that there is very little difference in the corrosion of iron or steel pipes.

In his paper on "Operating Economies in Heating Large Factory Buildings," Edward L. Wilder, of the Rochester Railway & Light Co., gave results from educating two large customers. One case was a four-story factory building built of brick. It had a total floor area of 60,000 sq.ft. and was heated entirely by direct radiation. By seeing that all windows were shut at the close of the working day, that the steam was entirely shut off and turned on again in the morning in time to have the factory comfortably warm by seven o'clock, the saving averaged 37 per cent. In another case a group of brick factory buildings, covering 75,000 sq.ft. of ground area and varying in height from 5 to 7 stories, were heated mainly by the fan system. An investigation followed by a specific set of operating instructions resulted in an average decrease in steam consumption of 32 per cent.

The discussion following the paper turned to intermittent vs. continuous heating. Mr. Boyden thought continuous heating more economical when the temperature was below 30 deg. F., and it resulted in better service. Others discussing the subject favored continuous heating at all times when the interval was not greater than 24 to 48 hr. Mr. Wilder strongly advocated intermittent heating. In many buildings, with steam left on, the temperature often ran up as high as 80 deg. during the night hours, so that the building loss was excessive. It was the opinion of President De Wolf that the method of operation would vary with different installations and that a choice must be made in each individual case.

Just before the convention adjourned, it was decided to appoint committees on underground construction and publicity. The afternoon was spent in visiting the plant of the Merchants Heat & Light Co., and other points of interest in the heating line.

In the entertainment Western hospitality was apparent. There were automobile trips to the Country Club and theater parties for the ladies, on Tuesday night a "get-to-gether" dance, buffet lunch and cabaret for all and on Wednesday evening a theater party.

Exhibits of underground conduit and heating specialties were made by the American District Steam Co., the V. D. Anderson Co., Armstrong Cork Co., Central Station Steam Co., Detroit Lubricator Co., General Electric Co., the Hardy Paint & Varnish Co., Jenkins Bros., H. W. Johns-Manville Co., the Michigan Pipe Co., the Ric-wil Underground Pipe Covering Co., the W. H. Schott Co., the Hohmann & Maurer division of the Taylor Instrument Co., and A. Wyckoff & Son Co.

Iowa N. A. S. E. Convention

The ninth annual convention of the Iowa State Association of the National Association of Stationary Engineers was held in Burlington, on May 21, 22 and 23, with the Hotel Burlington as headquarters.

The mechanical exposition of the Central States Exhibitors' Association, held in the banquet hall of the hotel, was formally opened on Wednesday at 10:30 a.m. At 1:30 p.m., State President A. E. Powell called the convention to order and Mayor F. C. Norton delivered the address of welcome. After National Secretary Fred Raven's response a visit was made to the shops of the Murray Iron Works Co., builder of Corliss engines and steam boilers.

At the evening exercises E. E. Egan, secretary of the Burlington Commercial Exchange, welcomed the delegates and visitors on behalf of that body and National President McGrath gave a brief address on "The Aims and Objects of the N. A. S. E." An informal smoker given by the exhibitors' association followed.

After the business session of Thursday morning, Adolph Shane, dean of the department of engineering at Highland Park College, Des Moines, lectured on "The Testing of Power Plants." After the afternoon business session C. A. Orr, chief engineer of the Morrell Packing Co., Ottumwa, lectured on "The Burning of Iowa Coal." Following this the delegates and friends went to the Burlington Base Ball Park as guests of the Riley Pennsylvania Oil Co., Burlington, and witnessed a game between the Burlington and Cedar Rapids teams of the Central Association. In the evening, a public reception was held by the exhibitors in the exposition hall.

Friday was taken up by an excursion down the Mississippi River to Keokuk on the "St. Paul," the delegates, visiting engineers, supply men and their families being the guests of the Murray Iron Works Co. The boat left Burlington at 8 a.m., and returned at 8:30 p.m. At Keokuk the mammoth dam and hydro-electric plant of the Mississippi River Power Co. was inspected. The final business session was held on the return trip, at which the following were elected to office for the present year: John Devine, Des Moines, president; Abner Davis, Cedar Rapids, reëlected secretary.

Throughout the convention ample entertainment was provided for the lady guests by a competent committee, including launch rides on the river, auto and trolley rides in and about the city and visits to Crapo Park, a natural beauty spot overlooking the Mississippi.

The next convention will be held at Des Moines.

Missouri N. A. S. E. Convention

The high standard established by the two conventions of the Missouri State Association of Stationary Engineers was fully sustained by the third annual convention which met at Springfield on May 14, for a three-day term. The number of delegates and guests was large and enthusiasm ran high.

At the preliminary exercises on Wednesday afternoon, the Rev. G. L. Peters made the invocation, after which O. M. Evans, chairman of the local committee, introduced Mayor George W. Culler, of Springfield, who welcomed the convention to the city. National Secretary Fred W. Raven responded on behalf of the association in the absence of President McGrath. State President F. H. Munsberg then delivered a brief address.

At this session, W. A. Vincent, chief inspector for the Missouri Fidelity & Casualty Co., gave a paper on "Steam Boiler Explosions," and Fred Key, another chief inspector for the same company, presented one on "Indicator Practice."

In the evening, Charles Cullen, secretary of the Central States Exhibitors Association, formally opened the exhibit in a hall at the Metropolitan Hotel by welcoming the delegates and visitors on behalf of his associates. Following an inspection of the exhibits an informal reception and entertainment were given by the exhibitors' association.

The convention proper was opened on Thursday morning by State President Munsberg, after an address by National Secretary Raven. In the afternoon another business session was held and at its conclusion a visit was paid to the new railway shops of the Frisco System, the ladies enjoying, in the meantime, an automobile ride about town as the guests of the Springfield Automobile Club.

In the evening Edward H. Lane, chief engineer of the Commerce Building, Kansas City, gave an instructive lecture on "Steam Boilers," and H. W. Hibbard, professor of mechanical engineering at the University of Missouri, Columbia, Mo., lectured on "Scientific Management in the Power Plant."

On Friday morning public exercises were held at which addresses were made by Secretary Charles Cullen, of the exhibitors association; Charles Parkinson, Missouri State deputy, and J. J. White, past state president. The annual election resulted in the selection of the following officers for the ensuing year: D. M. Trimble, Kansas City, president; J. H. Chesnutt, Springfield, vice-president; A. P. Maeder, Joplin, reëlected, treasurer; E. H. Lane, Kansas City, secretary.

In the afternoon a trolley ride was taken to Doling Park where a base-ball game was played by teams representing the engineers and the exhibitors, the former winning easily. In the evening a grand ball and public installation of officers was held at the Springfield Club.

Next year the convention will take place at St. Joseph.

Periodical Boiler Inspection in England

The following is taken from the annual report of the Manchester (England) Steam Users' Association:

It may be of interest to mention that the system of periodical boiler inspection inaugurated by the association in 1854 has been generally adopted in this country, and that now, aided by the Factory and Workshop Act, there are very few boilers remaining uninspected. In other countries, too, the system has been followed, so that the association may fairly be described as the parent of universal boiler inspection. In America, however, where inspection does not appear to have taken such deep root, the number of boiler accidents is still very great, in illustration of which it may be mentioned that, according to recently published statistics, there occurred in that country during the month of October last as many as 54 explosions, killing 20 persons and injuring 39 others.

Outside its ranks the association has noted throughout the United Kingdom during the year the occurrence of 68 explosions, killing 34 persons and injuring 49 others. Of these, 17, killing 9 persons and injuring 13 others, may be termed "boiler explosions proper," while the remaining 51, killing 25 persons and injuring 36 others, may be termed "Miscellaneous" explosions, i.e., those arising from steam pipes, stop valves, kiers, drying cylinders, bakers' ovens, economizers, etc. In addition to the above, one explosion arose from the bursting of a kitchen boiler, no personal injury resulting.

Air-Tank Explosion

On May 24, a huge tank of compressed air exploded at the plant of the Parrish & Bingham Co.'s foundry, Cleveland, Ohio. The engineer was thrown 15 ft. and severely injured. The building interior was partly wrecked and the windows broken.

Most of the foundry machinery is operated by compressed air. According to the daily press reports, the engineer had started the pumps to refill the tank and the pressure got too high before he noticed it.

Annual Exhibit of Day Work at Pratt Institute

The annual exhibit of the work of day students of Pratt Institute will be held as follows: Thursday, June 12, 2 p.m. to 5 p.m.; Friday, June 13, 10 a.m. to 5 p.m.; Saturday, June 14, 10 a.m. to 5 p.m.

This exhibit is open to the public and affords those interested in industrial and technical education an opportunity

not only of viewing the work of the students in the various courses, but also of inspecting the methods as well as the equipment of the school and its general facilities for conducting this kind of training.

The institute offers day and evening courses for both men and women in a wide variety of vocational subjects, including fine and applied arts, architectural design and construction and technical and trade courses for men along several important lines.

The work of the School of Science and Technology should prove of especial interest to men engaged in technical and trade pursuits. This school provides instruction in applied mechanics, applied electricity, applied chemistry and tanning, machine work and tool making; plumbing, carpentry and building and pattern making.

New University of Illinois Buildings

The recently completed transportation building, locomotive laboratory and mining laboratory at the University of Illinois, Urbana-Champaign, Ill., were dedicated on May 9. Simultaneously, a railway and a mining conference were conducted at the university.

The preliminary dedication ceremonies were held in the auditorium on Thursday evening, May 8, Dr. E. J. James, president of the university, presiding. Samuel Insull, president of the Commonwealth Edison Co., Chicago, spoke of the rapid progress made in the development of the science and business of generating and distributing electricity for light and power.

J. G. Pangborn, special representative of the Baltimore & Ohio Railroad, traced the history of railroad development from its very beginning and dwelt particularly upon the vicissitudes of the inventors of the early locomotives.

Capt. Robert W. Hunt, president of R. W. Hunt & Co., Chicago, spoke of the importance of conserving the coal resources.

The railway and the mining conferences convened on Friday morning at 9 a.m., and subsequently sessions were held Friday evening and Saturday morning. Many important and interesting subjects were discussed.

The dedicatory ceremonies were conducted in the Auditorium on Friday afternoon, Dean W. F. M. Goss, of the college of engineering, presiding. After Rev. Charles Ryan Adams, of the First Presbyterian Church of Champaign, pronounced the invocation, Dr. Edmund J. James, president of the university, delivered the address of dedication. The Hon. W. L. Abbott, president of the board of trustees, responded on behalf of Governor Dunne, who was unavoidably detained at Suringfield.

Prior to these ceremonies, a luncheon was served to the guests in the armory at 12:30, after which two hours were spent in inspecting the various university buildings and equipment. After the exercises, the assemblage, headed by the university band, marched to the main entrance of the transportation building where the Rev. Mr. Adams made a brief prayer of dedication.

The transportation building, the principal structure of the group, is a three-story building 143 ft. long and 65 ft. wide. It is designed primarily to be occupied by the department of railway engineering, but the upper floors are temporarily assigned to the department of mining engineering and the department of general engineering drawing. Accessory to this building is the locomotive laboratory, the mining laboratory and ceramics laboratory. The plan for the group of buildings of which these constitute a part provides for a railway electrical laboratory and a railway museum.

The locomotive laboratory is a brick and steel structure 117 ft. long and 43 ft. wide, and is served by a track connection with the Illinois Traction System. The laboratory is to provide means for testing locomotives under conditions similar to those prevailing in service. The mounting mechanism for receiving the locomotives to be tested is of original design and will accommodate the largest locomotive, not excepting those of the Mallet type. A locomotive mounted upon the testing plant may be fired and operated in the same way as upon the road.

Hydraulic friction brakes of enormous capacities mounted upon the axles of the supporting wheels serve to supply a load for the locomotive. The drawbar of a locomotive on the plant is coupled to a traction dynamometer, a device for measuring the pull exerted by the locomotive. The capacity of the dynamometer is such as to permit the measurement of a force as great as 125,000 lb. and yet it is so delicate as to permit great accuracy when the forces to be measured are small.

The main mining laboratory occupies a building 42 ft. wide and 100 ft. long, situated just east of the transportation building. It has four parts: 1. A chemical laboratory equipped with appliances for the analysis, assay and testing of coal and ore; 2. A drill and explosive laboratory containing regular machines and sectional models of the principal types of rock drills and coal cutters and appliances for testing blasting powders and for instructing students in the use of explosives; 3. A mine rescue station where the principal types of rescue apparatus are on exhibition and students are given instruction in first-aid and mine rescue work. 4. A coal-washing and ore-dressing laboratory. These laboratories are well equipped both for the instruction of students and for the testing of coals, ores and machinery. Tests of Illinois coals have already been run and a stock of gold ore from the Black Hills, lead and zinc ores, and fluorspar from southern Illinois are ready for future treatment.

PERSONALS

E. T. Scholer has been appointed manager of the electric-light station at Nezperce, recently acquired by the Grangeville (Idaho) Electric Light & Power Co., Ltd.

H. A. Mentz will be the engineer in charge of the Solomon-Norcross Co.'s branch office in Memphis, Tenn. Mr. Mentz is a member of the American Institute of Electrical Engineers.

J. P. Moore, formerly with the Westinghouse Electric & Manufacturing Co., has been made superintendent of power and equipment of the People's Incandescent Light Co., Meadville, Penn.

F. J. Derge has been appointed manager of light, heat and power for the Toledo (Ohio) Rys. & Light Co. Mr. Derge was, until his removal to Toledo, a member of the New York staff of H. L. Doherty & Co.

E. H. Clark has resigned as superintendent of power and shops of the Indianapolis, New Castle & Eastern Traction Co., New Castle, Ind., to accept a similar position with the Southern Illinois Ry. & Power Co., Harrisburg, Ill.

OBITUARY

HORACE G. BURT

Horace Greeley Burt, ex-president of the Union Pacific R.R. System and later chief engineer of the Chicago Association of Commerce Smoke Abatement Committee, died May 19. He was 64 years old.

STEPHEN D. FIELD

Stephen Dudley Field, F. Am. Inst. E. E., inventor of electrical devices, died at his home in Stockbridge, Mass., May 18, aged 68 years. He was born in Stockbridge and was a nephew of Cyrus W. Field, famous for having laid the first transatlantic submarine cable.

Stephen Dudley Field invented a multiple-call telegraph box in 1874 and an electric elevator in 1878; he was pioneer experimenter and inventor of electric railway equipment, and in 1879 he made the first application of dynamo machines to telegraphy. The following year he invented a dynamo quadruplex telegraph, in 1884 a fast stock ticker, and in 1909 made the first application of quadruplex telegraphy to submarine cables on the line between Key West, Fla., and Havana, Cuba. Mr. Field was also a member of the Institution of Electrical Engineers of Great Britain.

BUSINESS ITEMS

The Joseph Dixon Crucible Co., Jersey City, N. J., has issued a new brush booklet, which fully describes Dixon's graphite brushes for dynamos and motors. It is mailed on request.

An attractive folder has recently been published by the Griscom-Russell Co., 90 West St., New York, describing the Russell steam engines, Goubert feed-water heaters, Reilly multicoil heaters, Stratton steam-receiver separators and many other Griscom-Russell products. A copy will be mailed to anyone on receipt of request.

E. J. Rooksby & Co., 435 North 11th St., Philadelphia, have issued a booklet descriptive of a number of classes of engine repairs made by them and of their engine specialties designed to secure the highest efficiency and economy in the production of power. Copies will be mailed free to any interested parties.